

OXTS



xRED v1-S

USER MANUAL



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Introduction

This manual provides the information and guidance needed to understand, evaluate, and seamlessly integrate the xRED v1-S — enabling precise positioning from day one.

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 v1-S inertial navigation system is designed to precisely measure position, time, orientation, and dynamics for localisation, georeferencing, and validation applications. It is 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 v1-S 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 v1-S, 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 v1-S can be supplied in two kitting options: device-only or evaluation standard kit. The evaluation standard kit includes additional items that allow you to quickly and easily set up and evaluate the system.

Table 2 shows what is included in each kit variation.

Item	xRED v1-S – Device-Only	xRED v1-S (Evaluation) – Standard Kit
xRED v1-S inertial navigation system	✓	✓
xRED v1 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 v1-S scope of delivery

Hardware description

Overview

The xRED v1-S 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.

Design-in

Dimensions

xRED v1-S

Figure 1 shows the outer dimensions of the xRED v1-S, 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.

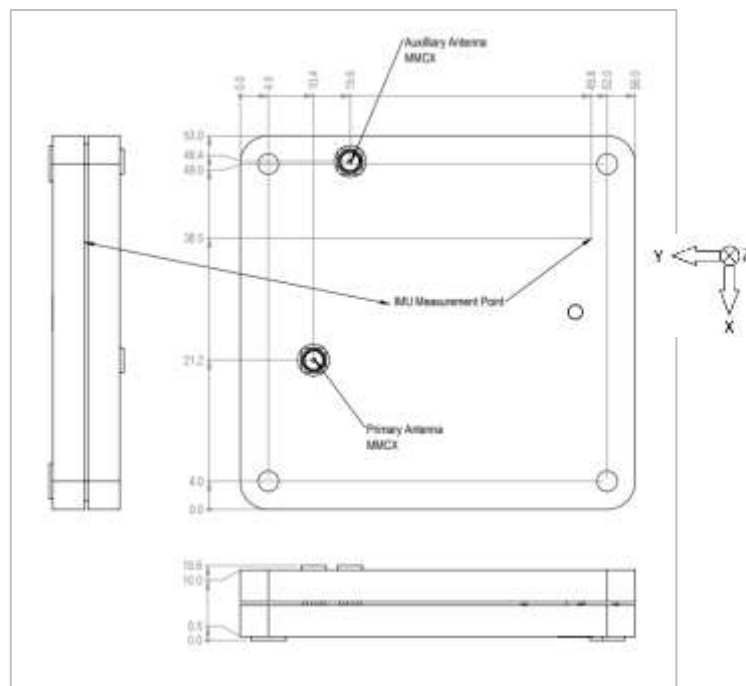


Figure 1:
Front view of xRED v1-S

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 v1-S is mounted with the Z axis vertical.

The xRED v1-S (and any external sensors used for georeferencing applications) must be isolated from any significant vibration greater than 5 Hz with damping isolators or shock mounts. Failure to do this will reduce the accuracy of navigation data.

xRED v1-S environmental considerations

For best performance ensure the xRED v1-S is not subjected to sudden changes in ambient temperature or strong air flow, both of which can adversely impact the internal sensors.

Pin headers

The main pin header is reference J1 on the PCB and has all of the critical connections required to use the xRED v1-S. The auxiliary pin header is reference J2 on the PCB and contains optional connections for the xRED v1-S. Figure 2 shows the locations of the centre of both pin headers and the pin positions.

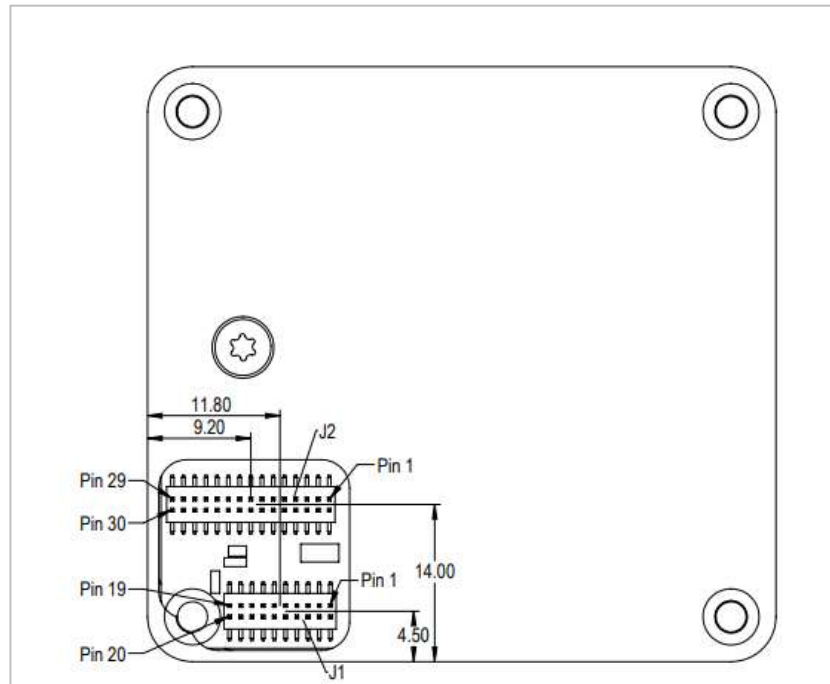


Figure 2:
xRED v1-S pin header locations for v1-S



WARNING. Care should be taken to ensure the pins are correctly aligned when interfacing with the pin header. Misalignment may cause electrical damage to the internal components.

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 5 V rail, or 5 V, 0.8 A 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 5 V 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 V. Leave floating if providing 5 V 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 3:
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: The signals on the AUX pin header are not essential to xRED operation and can be left disconnected if your application does not require them.

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 4:
J2aux header pin allocations

Voltage/power requirements

The main input supply accepts 6-60 V between voltage drain (VDD) and voltage source (VSS). VSS is connected to signal ground on the xRED v1-S 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 5 V to peripheral circuitry (up to 0.8 A) or as an input to supply power, bypassing the onboard PSU. If 5 V is supplied on the 5 V 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 v1-S is approximately 4 W. If the 5 V 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 efficiency, it's important to optimise the antenna setup. Poor-quality cables, unreliable connections, or excessive cable lengths can significantly increase the device's power consumption.

Interface voltage levels

Most I/O signals on the xRED v1-S 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 12 V wheel speed device is connected, the voltage must be clipped before the signal is passed to the xRED v1-S.

Interface details

Ethernet

A 4-pin Ethernet interface is the primary interface for configuring and monitoring the xRED v1-S. 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 KSZ9031RXN). Figure 3 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.

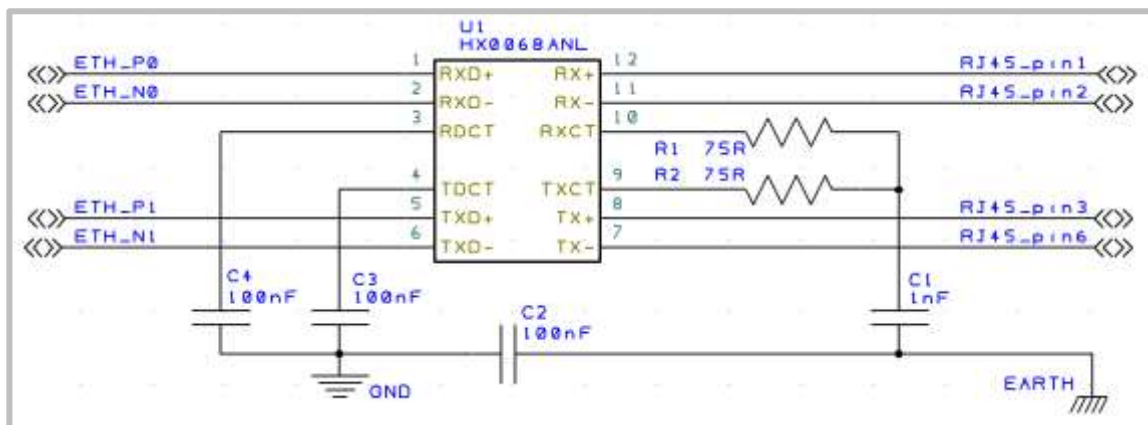


Figure 3:
Example ethernet transceiver wiring

Serial

The xRED v1-S has two serial ports whose inputs and outputs can be independently configured for several uses such as receiving corrections or outputting navigation data.

- + Serial 1 operates at RS232 voltage levels and can be used at rates up to 1MBd
- + Serial 2 is a 3V3 TTL interface connected directly to the CPU and can be used at rates up to 3MBd.

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.

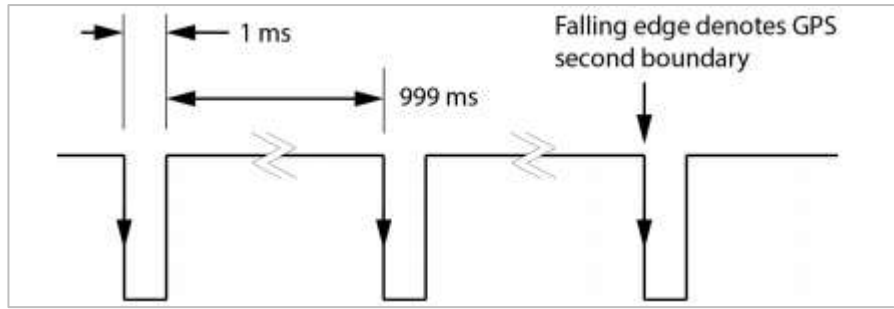


Figure 4:
PPS waveform

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 v1-S 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 are two LED outputs on the main pin header and four on the auxiliary pin header. These LEDs operate in pairs to indicate the status of various system functions. All the LED signal outputs from the xRED v1-S are active-low. The table below indicates what each LED is for.

The tables below provide both the LED statuses (high, low, or toggling) and factory-default colours, to help you interpret system behaviour during operation.

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 50 mA per LED.

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

Table 5:
LED 1 (main) behaviour

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

Table 6:
LED 2 (main) behaviour

Status LEDs

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



Note: We recommend buffering these signals if they are used to drive LEDs, as they are not buffered on the xRED board. If buffering is not used, the current must be limited to less than 10 mA per LED to prevent potential damage to the xRED.

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 7:
LED 1 and 2 (aux) behaviour

GNSS LEDs

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



Note: We recommend buffering these signals if they are used to drive LEDs, as they are not buffered on the xRED board. If buffering is not used, the current must be limited to less than 10 mA per LED to prevent potential damage to the xRED.

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 8:
LED 3 and 4 (aux) behaviour

Antennas

Antennas used with the xRED v1-S must, at a minimum, be capable of tracking the GPS L1 signal to ensure basic operation, and additionally the GPS L2 signal to support RTK performance. For optimal results and enhanced reliability, it is recommended that antennas also support the following signals:

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

For best results, use an active antenna with the xRED v1-S. The antenna output voltage is typically 5 V but can drop to around 4.4 V at 100 mA, which is the maximum current recommended per RF connection.

The antenna's Low Noise Amplifier (LNA) gain should be between 17 dB and 50 dB to ensure good signal quality without overloading the system. 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 v1-S uses MMCX connectors for the primary and secondary GNSS antennas. For a more secure and durable connection, we recommend using adapters to convert MMCX connectors to more robust types such as SMA or TNC.

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 5. 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.

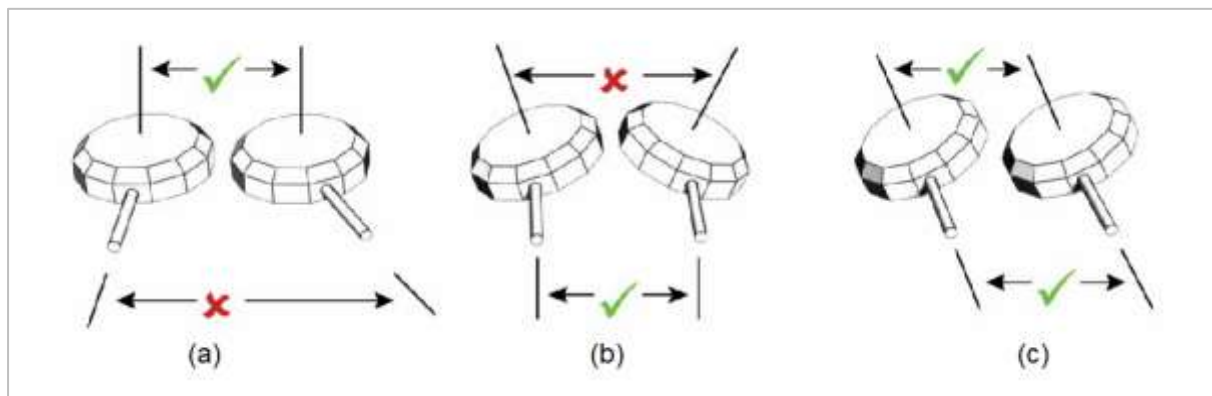


Figure 5:
Dual antenna orientation

- 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 v1-S 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 v1-S 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.

Configuration

The xRED v1-S must be configured before it can be used for the first time. To configure the xRED v1-S, follow these instructions:

1. Download and install the free NAVsuite range of applications [from the OXTS website](#).
2. Connect your xRED v1-S 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 v1 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 attaches to the xRED v1-S (Figure) and is designed to help you expedite your evaluation and initial integration. The evaluation board provides standard interfaces for the key connections, making it straightforward to set up and collect data.



Figure 6:
xRED v1-S with evaluation board attached

Dimensions

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

Figure 6 shows the dimension of the xRED v1-S evaluation stack. A CAD model is provided in the integrator pack.

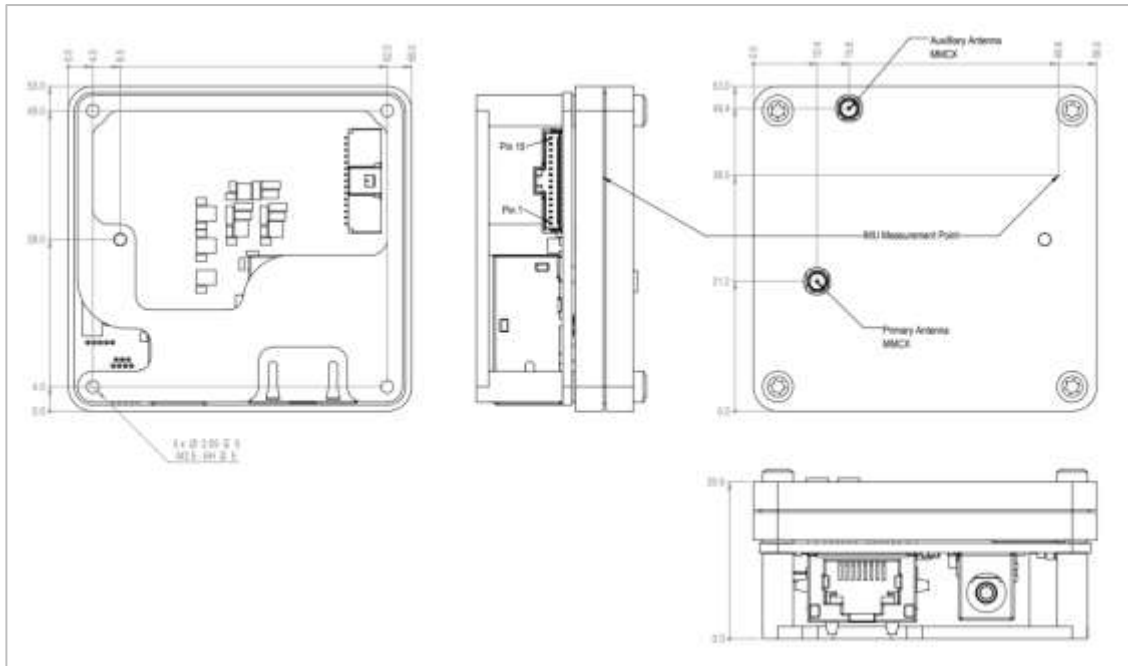


Figure 6:
xRED v1-S evaluation stack dimensions

Assembly

When attaching the xRED v1-S to the evaluation board, ensure that the connector pins line up correctly and that all four attaching screws are tightened to 30 N/cm.

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 evaluation board has four LEDs to indicate system status. Three LEDs are on the board itself, while the Ethernet LED is built into the Ethernet (RJ45) connector.

Additionally, the board includes a reset switch that restarts the system when pressed.

Evaluation board header pin allocation

Pin No	Signal	Comments
1	5 V	5 V input or 5 V, 0.8 A output. See Voltage/power requirements section 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	RS232 Tx	RS232 connection to transmit data to other sensors in your payload
5	RS232 Rx	RS232 UART2 connection to receive data from other sensors in your payload
6	Sig GND	
7	PPS	3V3 pulse per second from the primary GNSS card
8	Trigger 1	Trigger configurable for several different functions
9	Sig GND	
10	Srl TTL Tx	3V3 TTL UART connection to transmit data to other sensors in your payload
11	Srl TTL Rx	3V3 TTL UART connection to receive data from other sensors in your payload
12	Sig GND	
13	Wheel Speed A	Signal A of quadrature wheel speed input, or input for a single-ended wheel speed sensor
14	Whell Speed B	Signal B of quadrature wheel speed input
15	Trigger 2	Trigger configurable for several different functions

Table 9:
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 12 V 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.

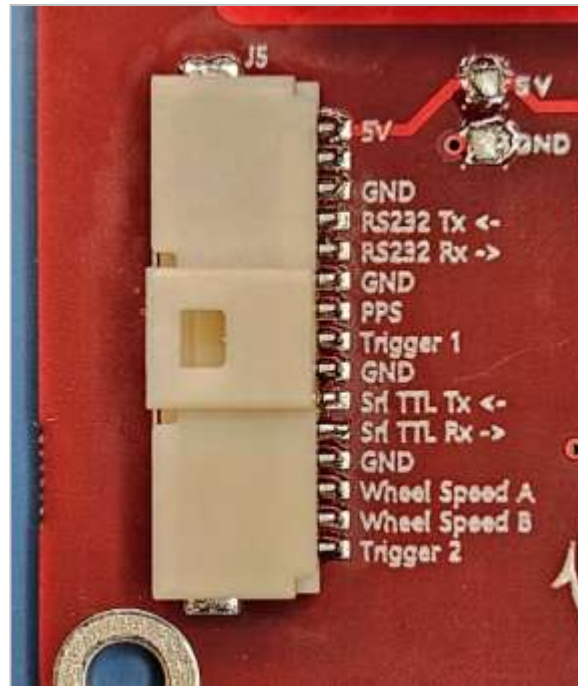


Figure 7:
Pin allocation on evaluation board silk screen

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 xRED v1-S.

Table 10 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 applicable)
	Ethernet output enabled and monitored during vehicle operation
	Vibration levels set to normal (higher levels 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)
	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 10:
Optimal operation checks

Revision History

Revision	Changes
250722	First release
251208	Added warning regarding pin header misalignment

Table 11:
Revision notes



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