Hardware Integration Manual

xRED3000

High-performance GNSS/INS for accurate localisation, even in harsh environments

Measure with confidence OXTS

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Revision

Document Revision: 230315 (See Revision History for detailed information).

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Introduction

The purpose of this manual is to give users the information they need to evaluate and integrate the xRED3000 from OxTS into their existing payloads.

We would love to hear any feedback you have on the xRED3000 after having used it – please get in touch with your OxTS representative or email jdeacon@oxts.com to send us your feedback or arrange for a call.

2. Dimensions and mounting

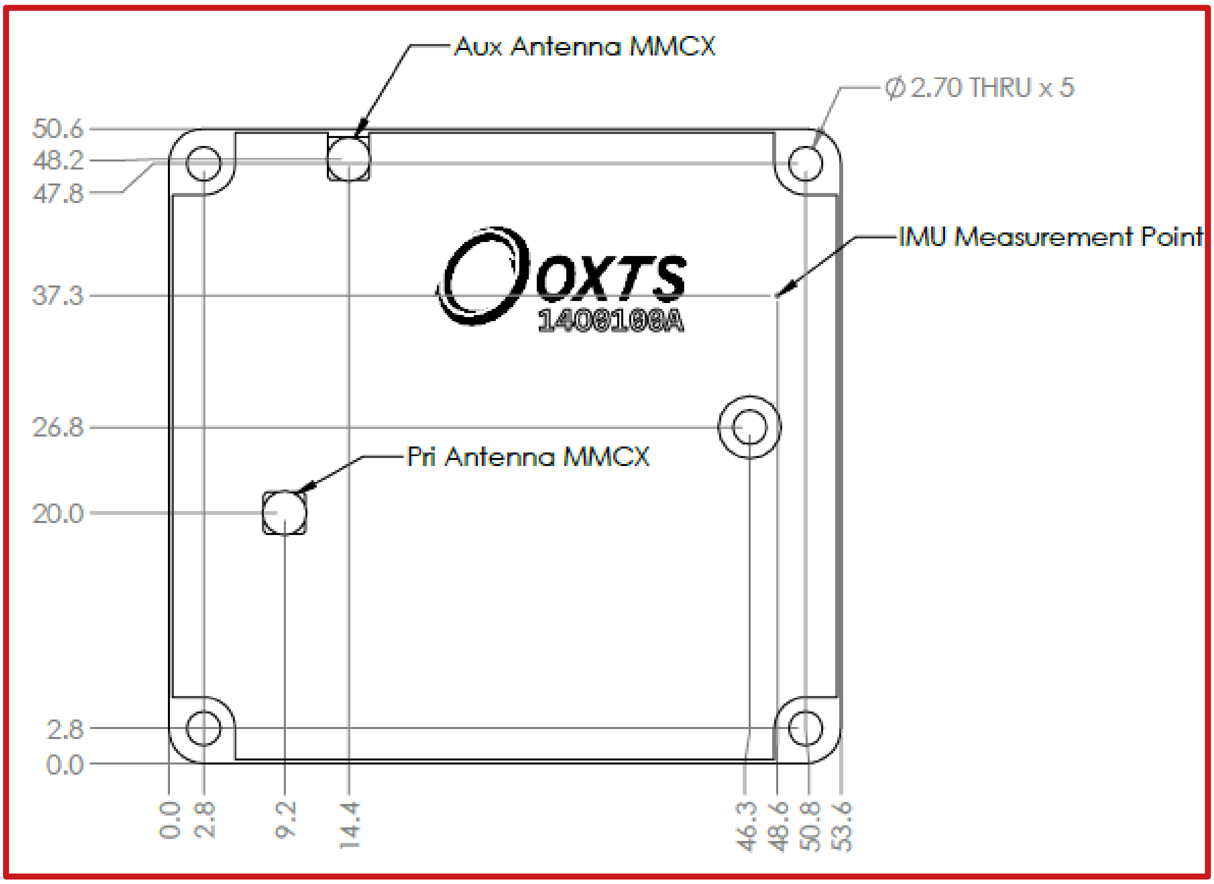
2.1 mounting the board set

Below you can see a front-on view of the xRED3000. It shows you the dimensions of the PCB, the five mounting points, and antenna connector locations. See section 4.1 for a diagram of the correct orientation for the xRED3000.

You should use M2.5 screws to secure the board in place at each mounting point. There's a 2.5mm high keep out area on both sides of the PCB to allow for the mounted components and the PCB is 1.6mm thick.

Due to the xRED3000's minimalist design, you will either need to mount it to a separate board, or into your payload, before mounting it to the vehicle – whichever fits best with your design. However you build the xRED3000 into your payload, it's vital that the INS is securely fixed to the vehicle frame for it to function properly. Take care when mounting that you don't put the PCB under undue strain – apart from the normal risks of putting a PCB under strain, additional strain could impact the performance of the IMU, which in turn will impact the performance of the whole INS.

Your payload (the xRED3000 and any additional sensors attached to it) must be isolated from any significant high-frequency vibration (greater than 5Hz) with damping isolators or shock mounts. Failure to do this will reduce the accuracy of your orientation measurements.

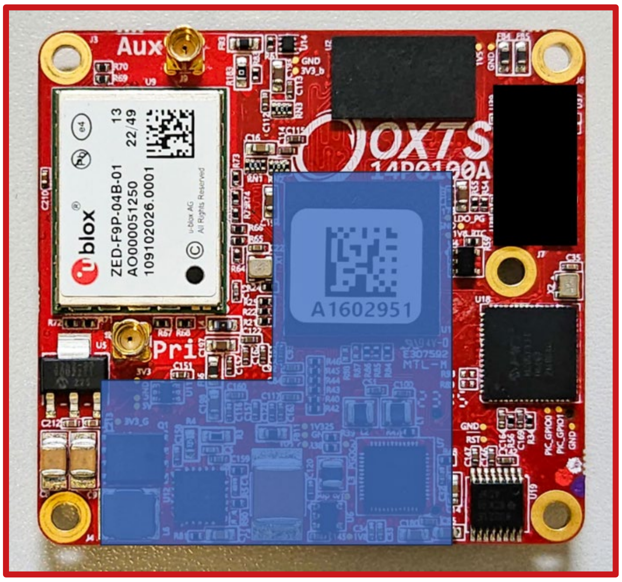


This diagram along with side and rear views are also in the separate PDF document.

2.1 heat sinking considerations

If you can, we advise that you provide heat sinking to the xRED3000 to allow it to better dissipate its heat. The inductor on the output of the PSU is one of the main components that is at risk from overheating; in rare circumstances where other components on the board are approaching their specified limits, there is a risk that the inductor will exceed its specified maximum operating temperature of 125°C and potentially become damaged without heat sinking.

The blue area in the picture below indicates where heat sinking should be applied.



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 in the xRED3000 becomes.
2. The input voltage used. At higher voltages, the xRED3000’s PSU becomes less efficient 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 our testing at room temperature with dual antennas connected include:

- A 12V input voltage, with 4W being drawn from the 5V output line the inductor sits at ~102°C which is comfortably below its limit of 125°C.
- A 60V input and no load operates at a similar temperature.
- A 60V input voltage with a 4W load on the 5V output line causes the inductor to reach 137°C – above its specification.

Our NAVdisplay software provides you with an IMU temperature output that can be used as an indication of how hot your xRED3000 is running, though it’s important to note that this is a guide only and does not provide a definitive indication of the temperature of the inductor.

3. Interfacing

3.1 Antenna connectors

The antenna connector positions are shown in the diagram above. They are MMCX sockets such as this one from TE Connectivity (part number 1-1634009-0). These can be connected directly to some antennas, but if needed they can be used with SMA or TNC adapters. Please note that for the best performance, we recommend that you use an active antenna – that is, one that is powered.

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.

Both GNSS receivers support the following frequencies:

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

To get the best performance, your accompanying antenna should support these frequencies too.

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

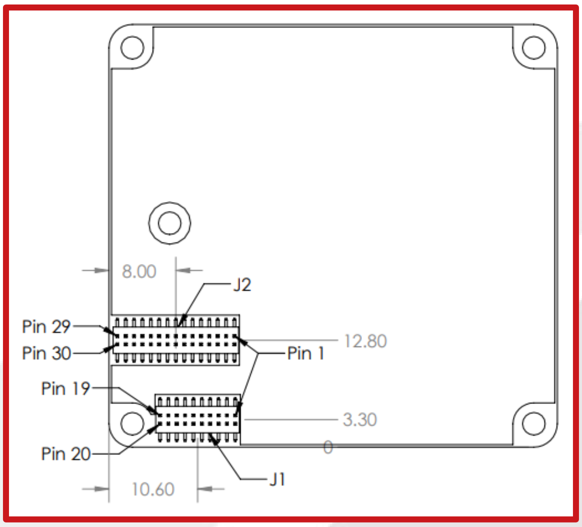
For reference, we have tested the board with the following antennas:

- Tallysman TW7972 SMA
- VEXXIS GNSS-502 TNC
- VEXXIS GNSS-802 TNC

3.2 J1 Main pin header

The main pin header is reference J1 on the PCB and has all of the critical connections required to use the xRED3000. The part number of the header used is FTMH-110-03-F-DV-A and the recommended part number of the mating header is CLM-110-02-F-D-P.

The below diagram shows the locations of the centre of both pin headers and the pin positions. The table below that shows the pin allocation for the main connector.



3.2.1 J1 Main pin header allocations

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

3.3 J2 Auxiliary pin header

The auxiliary pin header is reference J2 on the PCB and contains optional connections for the xRED3000. The part number of the header used is FTMH-115-03-F-DV-A and the recommended part number of the mating header is CLM-115-02-F-D-P.

Note that, as the first 10 pins on this header are not currently for customer use, you could use two CLM-110-02-F-D-P headers instead, leaving the first 10 pins of the auxiliary header unconnected.

None of the signals on this pin header are vital to the operation of the xRED3000, so you can leave it disconnected if your application does not require any of the signals on it.

3.3.1 J1 Auxiliary pin header pin allocations

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

3.4 Voltage/power requirements

The main input supply accepts 6-60V between VDD and VSS. VSS is connected to signal ground on the xRED3000, but through some filtering – so for best EMC performance it should be connected to the negative terminal of the power source only. This will keep the signal ground clean.

As we've mentioned in the table above, 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 xRED3000's 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 power required by the xRED3000 is anticipated to be around 3-4W. If you're using the 5V pin to power auxiliary circuitry, then the power required will be higher.

A note on power efficiency…

If you're trying to be as efficient with your power consumption as possible, it's important to pay attention to your antennas. Poor-quality cables and connections, and longer cabling, can increase the power consumption of your antennas and become a significant part of the total power consumption.

The power consumption we quote on OxTS products is measured using the standard 5m antenna cables we ship with our units. If your application allows it, using a shorter cable will keep power consumption down.

3.5 Interface voltage levels

Most IO signals on the xRED 3000 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, which is RS232 voltage levels
- Ethernet, which is 100BASE-T

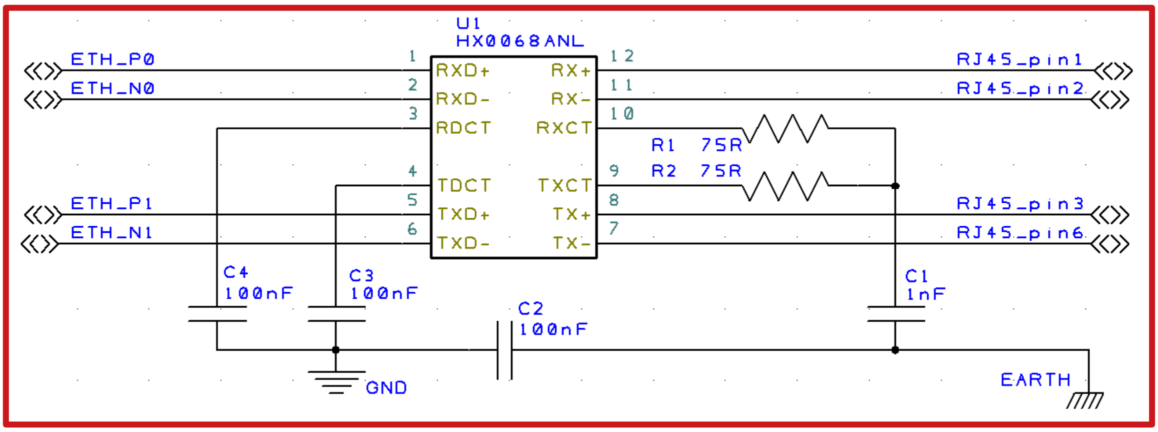
Doing things this way keeps the footprint of the xRED3000 to a minimum. However, it does mean that if you want to connect anything not compatible with 3V3, level translation or clipping must be done on the mating board to avoid damaging the xRED3000.

For example, if you want to connect a 12V wheelspeed device the voltage must be clipped before the signal is passed to the xRED3000.

3.6 Interface details

3.6.1 Ethernet

A 4-pin Ethernet interface is available from the XRED3000 and this is the primary interface for configuring and monitoring the XRED3000. The Ethernet PHY used supports MDI, so it doesn't matter where you connect each pair on the socket, as long as the pairs +/- match. Note that external ethernet transformers are required. Below is an example of how these should be wired to work with the PHY we use (KSZ9031RNX). It's important to note that RJ45 sockets regularly come with ethernet transformers integrated; if yours does, then you don't need to add additional ethernet transformers.



3.6.2 Serial

The XRED3000 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 because it goes through an onboard transceiver, which limits the rate to 1MBd.

As most users will only require one serial port, the idea is that you pick the port with the interface that suits your purpose best, with no need for external circuitry. However, if you want to use two connections of the same type (such as two RS232-level serial ports), an external transceiver will be needed.

3.6.3 Pulse per second and IMU synchronisation signals

The PPS signal comes from the GNSS card and is a 1ms pulse on the second boundary. You can configure which edge of the signal is used for synchronisation, otherwise the system will default to the falling edge. 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 xRED3000 is synchronised to the falling edge of the IMU sync.

3.6.4 Triggers

The two triggers are configurable as inputs or outputs and can be used in a variety of ways. For example, you could configure an input to trigger an output packet synchronised with an event. Triggers can be configured using NAVconfig as you would with any other OxTS INS (click here for instructions on how to do this).

3.6.5 Wheelspeed sensor input

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

3.6.6 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 xRED3000 are active-low. The table below indicates what each LED is for.

A note on LED colours

All other OxTS devices use red and green LEDs (giving us red, green, and orange colours to work with). You are of course free to choose your own LED colours, but we recommend that you use the same colours as OxTS to make support easier. In some of the tables below we have given you both the LED statuses (high, low, or toggling) and the colours you would see on another OxTS INS 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 xRED3000.

Ethernet LEDs (LEDs 1 and 2 on the main pin header)

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

LED 1	
Pin State	**Activity**
High	No activity
Toggle	Activity (receiving or transmitting data)

LED 2	
Pin State	**Link**
High	Link off
Toggle	Link on (any speed)

Status LEDs (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 xRED3000 board. If you do not use buffering, the current should be kept below 10mA per LED to avoid damaging the xRED3000 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) = toggling LED 2 (aux) = high	The operating system has booted but the GNSS receiver has not yet output a valid time, position, or velocity.	Red flash
LED 1 (aux) = low LED 2 (aux) = high	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) = high LED 2 (aux) = low	The INS is running and the system is real-time.	Green

GNSS LEDs (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 xRED3000 board. If you do not use buffering, the current should be kept below 10mA per LED to avoid damaging the xRED3000 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) = toggling LED 4 (aux) = high	The GNSS receiver is active but has not yet determined heading.	Red flash
LED 3 (aux) = low LED 4 (aux) = high	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) = high LED 4 (aux) = low	The GNSS receiver has an integer (good) calibrated heading lock.	Green

4. Configuring

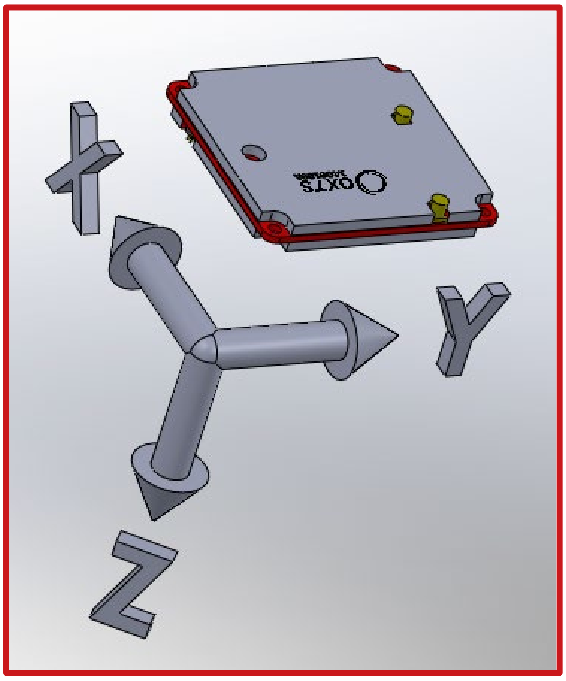
All OxTS devices need configuring before they can be used for the first time. To configure the xRED3000, follow these instructions:

1. Download and install the free NAVsuite range of applications from the OxTS website.
2. Connect your xRED3000 to your computer via ethernet.
3. Launch NAVsuite, and from there launch NAVconfig.
4. Select 'new configuration', 'connect to device'.
5. Either select the xRED3000 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.

4.1 Orientation

The image below shows the orientation of the unit so this can be aligned correctly to the vehicle during the configuration process.



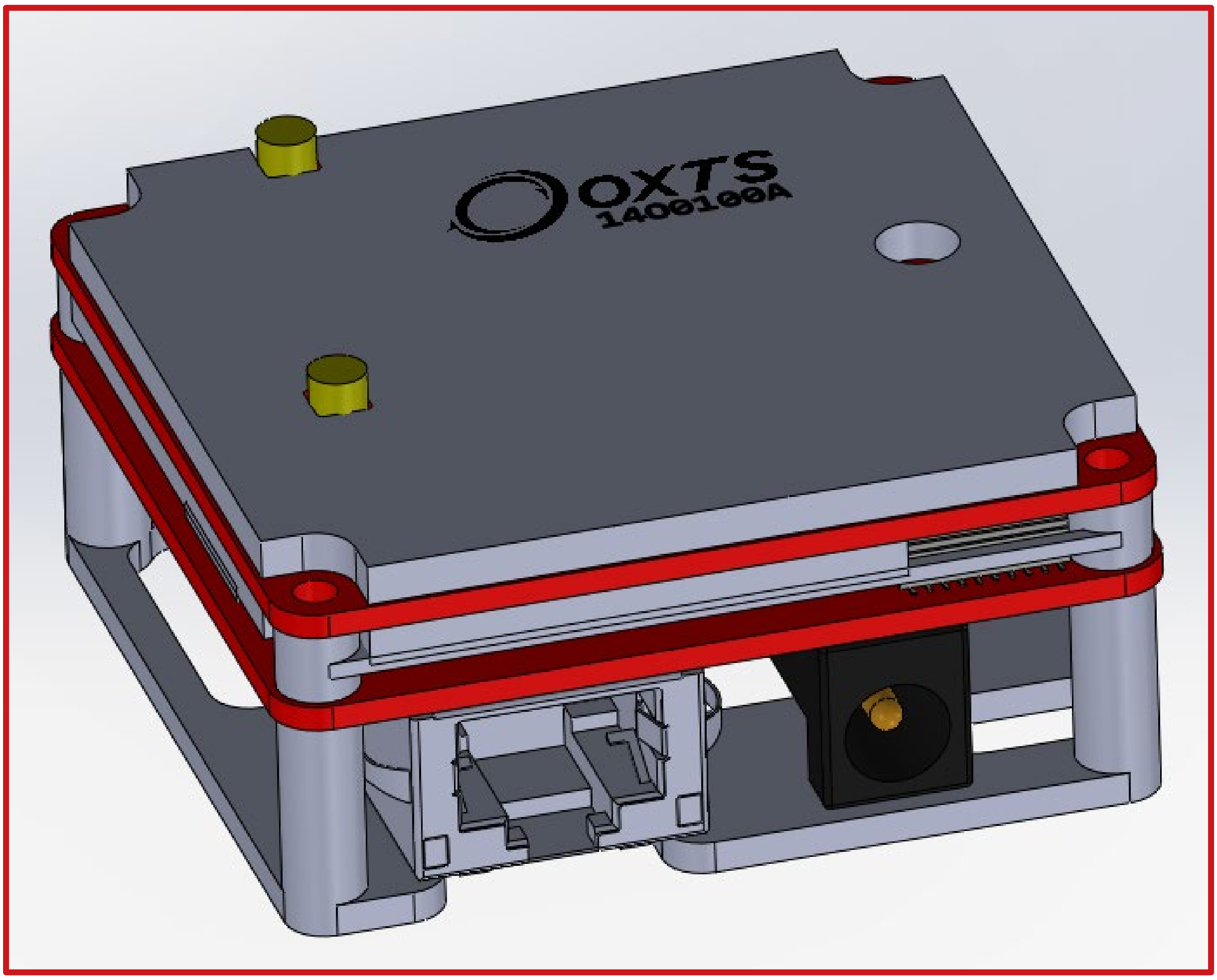
5. Evaluation board

The evaluation board is designed to make evaluation of the xRED3000 more convenient. The evaluation board provides standard interfaces for the key connections, making it straightforward to set up and collect data.

5.1 Dimensions and mounting

The dimensions and mounting points of the evaluation board match that of the main board set. A set of aluminium frames allow you to sit the unit stably on a desk or mount it to a vehicle by screwing into the tapped corner holes. A CAD model is provided in the integrator pack to aid design of your payload.

Below is an image of what the xRED3000 looks like with the evaluation board attached.



5.2 Interfacing

The evaluation board provides a standard RJ45 connector for connecting to Ethernet and a DC barrel connector (part number, 694106106102) from Würth Elektronik for powering the unit. On top of this there is a standard header (part number, 501568-1507) from Molex that gives you access to the other available interfaces. The part number for the mating part is 5013301500 and pre-crimped leads are available in 300mm, 797581019, or 150mm, 797581018 (all Molex parts).

Below we've detailed the pin allocation for the pin header on the evaluation board, which is also indicated on the board's silk screen for easy reference. Pin 1 is the pin closest to the RJ45. 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 wheelspeed which have some voltage clipping on them to allow sensors such as a 12V wheelspeed sensor to be used.

5.2.1 Board pin header pin allocation

Pin No	Signal	Comments
1	5V	5V input or 5V, 0.8A output. See section 3.4 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 wheelspeed input, or input for a single-ended wheelspeed sensor
14	WS2	Signal B of quadrature wheelspeed input
15	Trigger 2	Trigger configurable for a number of different functions

Additionally, the evaluation board includes a reset switch that will reset the system. 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.

6. Revision History

Revision	Changes
230315	First release for sharing with prospective customers ahead of the production of the first prototypes.

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