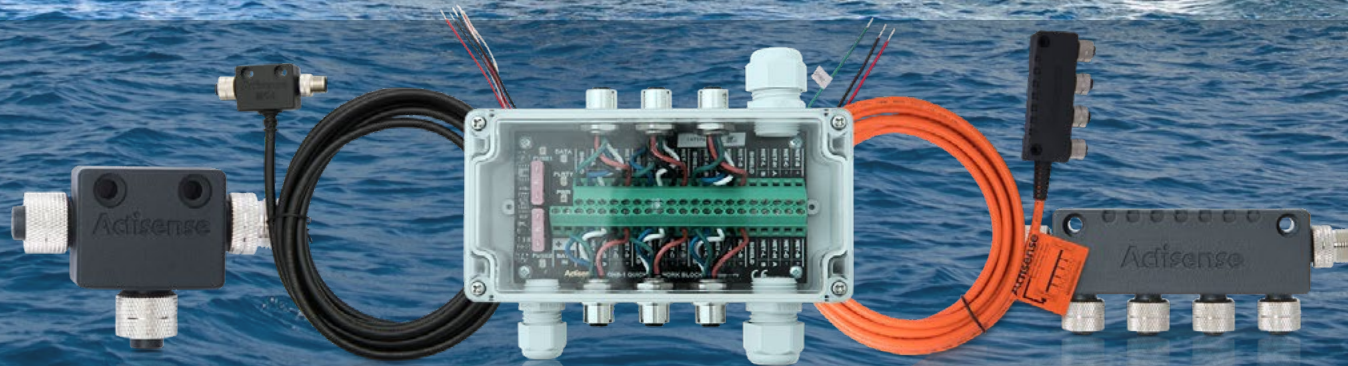


The Ultimate Guide to NMEA 2000® Networking



Actisense®
Award Winning NMEA Specialists

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1. What is NMEA 2000?

Who are the NMEA?

The NMEA stands for National Marine Electronics Association. In a nutshell, they're a not for profit organisation whose mission is to improve data communications between marine electronics manufacturers. Read more at www.nmea.org

What is NMEA 2000?

NMEA 2000 is an open standard designed by the NMEA to help them achieve their mission by standardising the messages and connector system used for devices in the marine industry. There is a common misconception that the term 'open standard' means freely available when in fact it means that the standard is available to buy at a reasonable cost from their [website](http://www.nmea.org). It is important to remember that the NMEA is not for profit (NFP) and the standards create an important source of income so that they can continue to exist.

The Network That CAN

NMEA 2000 is based on a system known as CAN which stands for 'Controller Area Network'. One of the reasons the NMEA chose this system over something like Ethernet (for example) which has a much wider bandwidth, and can support RADAR and video, is because CAN has the ability to guarantee message delivery even when the network is 100% loaded. An important feature when you consider that the network is likely to contain important GPS information.

DeviceNet

The NMEA adopted the 'DeviceNet' standard for the hardware (cables and connectors) that is used to create an NMEA 2000 network. The DeviceNet standard was already in use by the automotive and agricultural industries (to name a few) so it is a proven robust system and can withstand the harsh conditions of the marine environment.

Certification

There is a certification process in place for NMEA 2000. This helps the user to understand that if a device carries the NMEA 2000 logo they can rest assured that it is compatible with an NMEA 2000 network and any other 'NMEA 2000 Certified' device. Some common terms for the user to be aware of are 'CANbus approved' or 'NMEA 2000 Compatible' as these are unlikely to have gone through the NMEA 2000 certification process.

'NMEA 2000 Approved' is a term used for cables and connectors that meet the requirements for NMEA 2000 as they do not require the same certification process.



2. Why use NMEA 2000?

What is the difference between NMEA 2000 and NMEA 0183?

NMEA 2000 simplifies the connection - The NMEA 2000 backbone is a single trunk cable to which the appropriate T-pieces, network cables and terminators can simply screw onto. Unlike connecting NMEA 0183 open cable ends.

What are the advantages of NMEA 2000?

- It's simple connection makes an NMEA 2000 network easy to install.
- NMEA 2000 networks are reliable. They are self-configuring and no setup is required, meaning you can easily add or remove any compatible equipment without needing to restart the network.
- Unlike NMEA 0183, having different baud rates is not an issue with NMEA 2000 networks.
- NMEA 2000 networks can allow up to 50 different compatible devices to connect to each other.
- You do not have to replace your entire NMEA 0183 network when converting to NMEA 2000. You can easily hook up to the new network whilst keeping currently installed NMEA 0183 devices using an NMEA 2000 Gateway like the [NGW-1](#).



3. Minimum Network Requirements

Minimum Network Requirements

The following are the essential components of any NMEA 2000 network:

- Power insertion point - fused.
- 2 x NMEA 2000 certified devices (at least 1x TX and 1x RX) and a means to connect them to the network. This can be via T-pieces or other products which will be discussed later.
- Termination resistors - Precisely 2, no more, no less.

Common Phrases

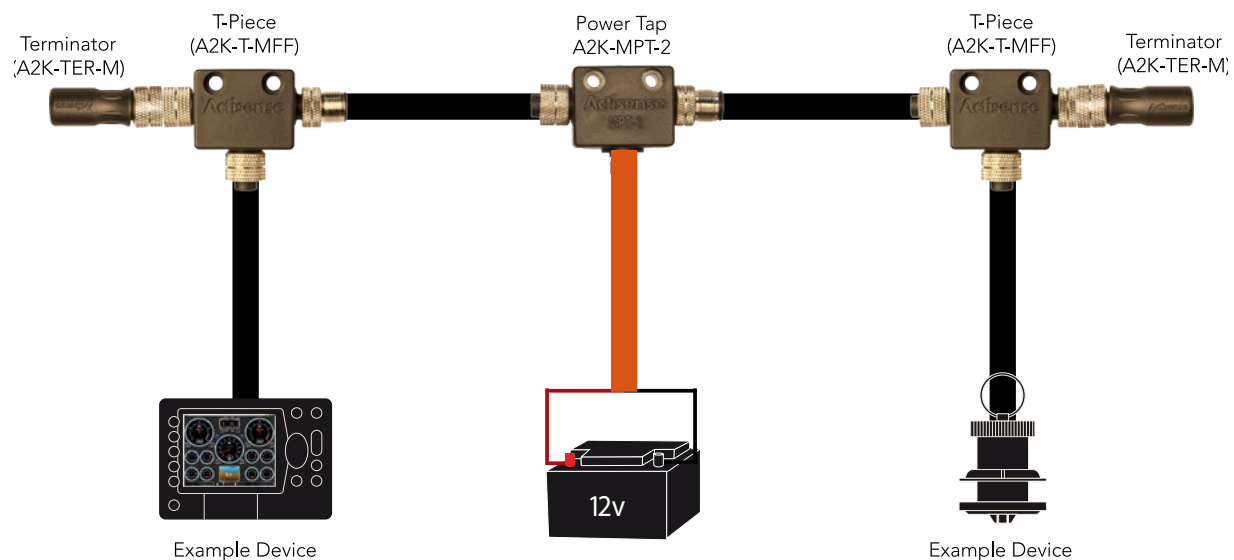
You will hear some common phrases used when discussing NMEA 2000 networks. Here's what they mean:

Backbone: The main trunk of cable that runs through the boat to form the network. T-pieces are connected along the network for devices to plug in to.

Instrument drop: The length of cable that connects an NMEA 2000 device to the backbone

PGN: Stands for 'Parameter Group Number'. The messages used by NMEA 2000 devices for sharing information.

The diagram below illustrates how an NMEA 2000 network is put together:



4. NMEA Cable Limitations



In order to achieve a compliant NMEA 2000 network, the following table indicates the technical specifications required for your NMEA cables:

Cable Type	Max Length	Max Amp	Power Pair	Data Pair
Per drop cable	6m			
Sum of all drop cables	78m			
Micro/Lite Backbone (Terminator to terminator)	100m	3	22 AWG	24 AWG
Mid backbone (Terminator to terminator)	250m	4	18 AWG	20 AWG
Mini/Heavy Backbone (Terminator to terminator)	250m	8	15 AWG	18 AWG

*AWG = American Wire Gauge

5. Network Power

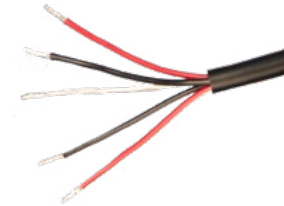
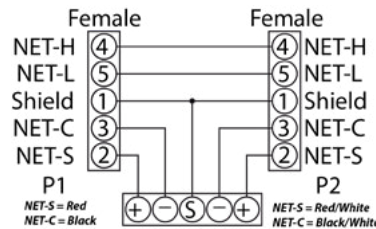
As mentioned, power is a key imperative element of any NMEA 2000 compliant network. Our team at Actisense have created a series of different power options to suit your vessel:

Power Insertion using A2K-MPT-2

The Actisense Micro power T-piece has a twin pair of power wires, one for each side of the T-piece. Both pairs must be connected to a 12/24 Volt power supply (via fuse panel) so that the electrical load can be distributed evenly.

When using 24V systems, a warning must be installed on the network to ensure anyone installing new devices is aware. This is because the NMEA 2000 specification doesn't officially support 24V but this level of power supply can be used if installed devices are capable of supporting it. All Actisense devices support 24V power supplies.

The illustration below details the internal wiring of the Actisense power T-piece. Note the pair of positive and negative pins on each side.



Power using A2K-MPC-1

This micro power cable is designed for small installations that will be used with the A2K-KIT-3 so it only has a single pair of power wires. The MPC has a Micro DeviceNet connector so that it can be easily plugged in to the most suitable port on the 4-way T-piece provided. The MPC should never be used on larger installations.

Power using A2K-SBN-1 / SBN-2

The power cord for the Small Boat Network is over moulded to the case of a 4-way / 8-way T-piece to prevent water ingress. Power is available to all 4 / 8 ports once the pair of bare wires is connected to a 12V or 24V power supply.



Network Power Continued...

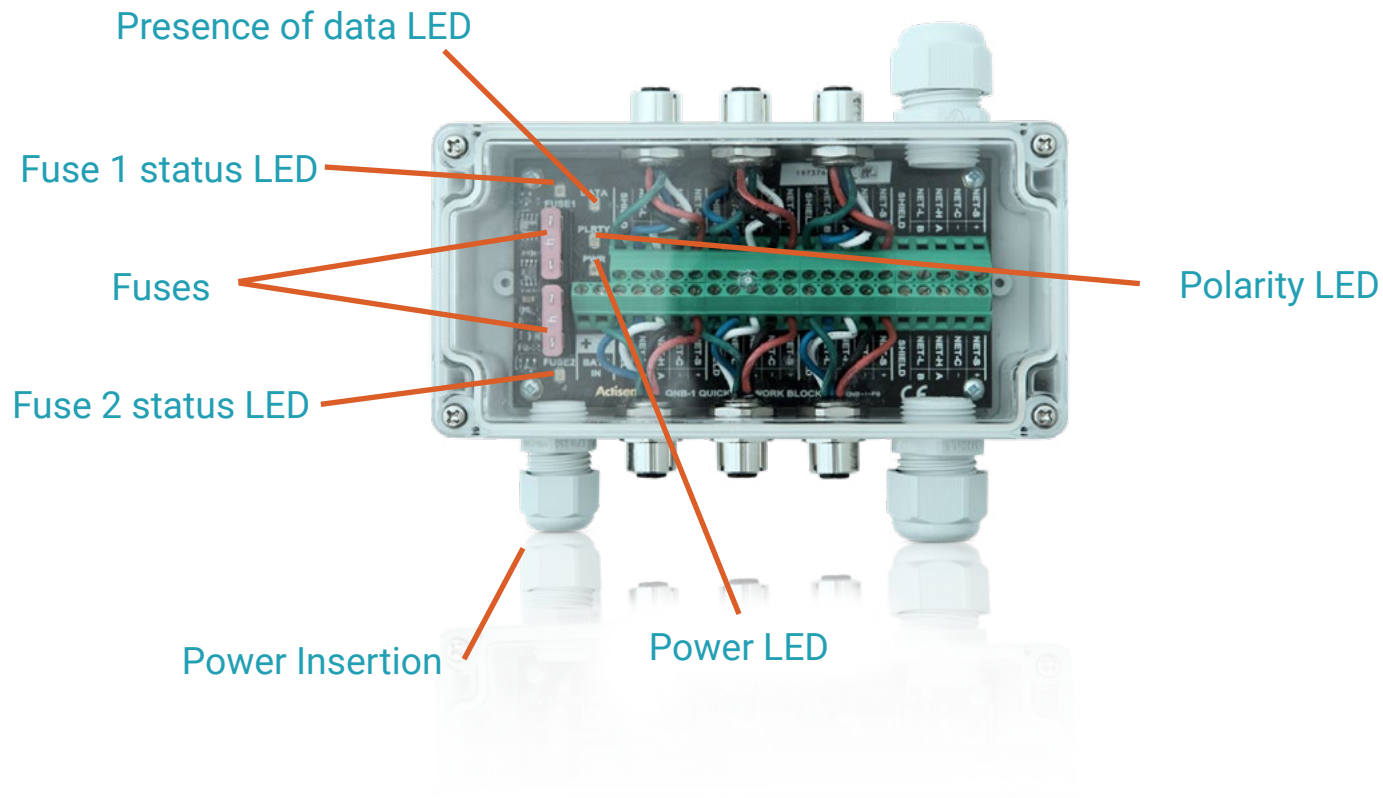


Power Insertion using Quick Network Block (QNB-1)

The Actisense Quick Network Block (QNB-1) provides a versatile and easy to install solution for any NMEA 2000 network, utilising high quality NMEA 2000 barrier strip connections. With glands fitted to the QNB-1, it allows for custom lengths of cable and cable mixing, meaning that the QNB can be implemented with Raymarine STNG cables for example.

The QNB-1 splits the power feed with separate fusing on either side, enabling longer networks with isolation due to the ATO fuses.

The other version (QNB-1-PMW), comes with 6 x M12 Standard Female (Micro) Connectors, allowing for 'plug and play' with drop cables.



6. T-Pieces & Terminators

Micro T-Pieces: A2K-T-MFF

T-pieces can be connected directly to the Power T or you can use a length of NMEA 2000 approved cabling to extend the backbone and join the T-piece to the end of the cable. The instrument drop must be connected at right angles to the backbone to keep the Network topology consistent.

4-Way T-Piece: A2K-4WT

The 4-Way T-Piece can be used where multiple drops are required in close proximity or where space is limited. The A2K-4WT takes up the same amount of space as 2 individual T-Pieces connected together, and costs less than 4 individual T-Pieces.

Terminating Resistors: A2K-TER

Each end of the NMEA 2000 Backbone must have a terminator installed. The terminators are 120 ohms each, which when connected, join across the data wires in parallel, providing 60 ohms resistance to the network. Terminators are essential to maintaining data integrity on an NMEA 2000 network.

Smart Universal Micro Terminator: A2K-TER-U

The A2K-TER-U is the world's first intelligent universal inline terminator. It can be placed either as an inline terminator, or as a M / F Terminator at the end of the network. The intelligence in the terminator can act as an instant diagnostic tool, indicating the voltage levels on the bus.

Above 9V = GREEN

Below 9V = RED



7. Drop Cables and Backbone Extension

Trunk & Drop Cable: A2K-TDC

If the length of cable required between T-pieces/devices is known, pre-assembled cables can be used for extending the backbone or plugging in devices to the network. This option saves a lot of time not having to cut the cable and wire a connector to it yourself. Actisense NMEA 2000 approved cabling is available in the following sizes:

- 0.25m
- 0.5m
- 1m
- 2m
- 3m
- 4m
- 5m
- 6m (maximum length that can be used for an instrument drop as defined by the NMEA 2000 specification)
- 8m
- 10m



Bulk Cable: A2K-BULK-100M

If customised lengths of cable are needed, or lengths of cable greater than 10 metres, bulk cable is available in 100 metre reels. This can be used together with Actisense field fit connectors.



8. Field Fit Connectors

Field Fit Connectors: A2K-FFC

When bulk cable is used a connector will need to be wired to the ends so that the cable can be plugged in to the network or a device. Follow our five steps to field fit installation success on the next page that illustrates the best method for installing field fit connectors, including which colour wires connect to which pins.

The NMEA 2000 wiring colour system is standardised so the colours and pin numbers will be the same for any wire and connector combination that uses the same DeviceNet standard.

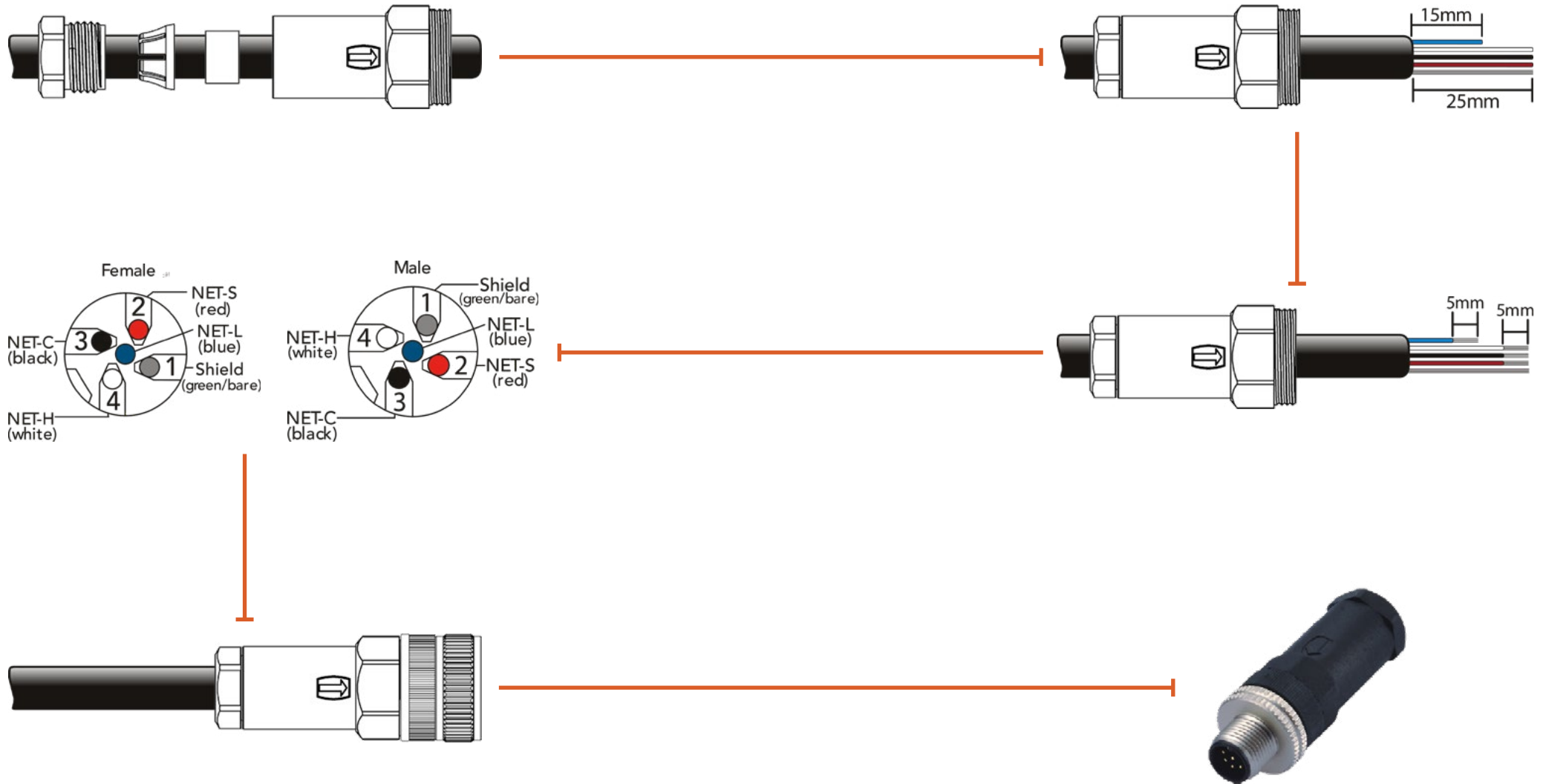
Actisense Field Fit Connectors are available as straight or right angled options and in male and female variants to suit any installation requirement.



Note the plastic sleeve that covers the centre pin. This is to prevent the bare wires that extrude from the other 4 pins making contact with the copper and creating a short. Not all field fit connectors have this plastic sleeve.

9. Steps to Field Fit Connector Success

In order to successfully connect your Field Fit Connector please follow the below guide:



10. Quick Network Block In-Depth (QNB-1)

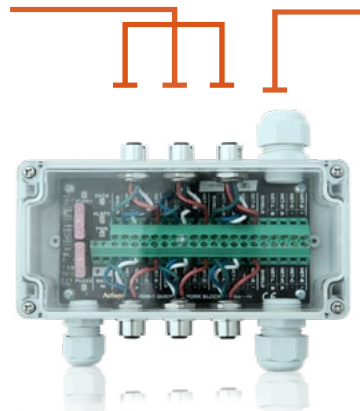
Detailed Overview

The Actisense Quick Network Block (QNB) provides a simple 'network in a box' solution. It can be used in areas of high instrument density when devices are up to 12 metres apart from each other (6 metre drop from device to QNB per device). Another popular use for the QNB is with engineers that have a need to create a small NMEA 2000 test environment on a workbench (for example).

This page provides a brief explanation of the [QNB-1](#), and how Panel Mounts connectors and blanking plugs connectors can be used with the device.

Wire Colour	Connects to
Red	NET-S
Black	NET-C
White	NET-H
Blue	NET-L
Bare/green	Shield

Instrument drops



Backbone connections

Labels are the same for both sides and for both variants of QNB-1.

See the next page for more information on the different variants available.

Panel mounted wire connectors ([A2K-PMW](#)) are available as a stand alone product for creating through bulkhead connections. They can also be used to replace the connectors in the QNB if needed.

Panel Mounted Connectors (Bulkhead): [A2K-PMW](#)



Blanking plugs are also available to protect any unused panel mounted wire connectors from water splashes.



Blanking Plugs: [Purchasable via Dealer / Distributor.](#)

QNB-1 Continued...



Raymarine SeaTalkNG integration of cables

The QNB also offers the ability to mix and match DeviceNet standard connectors with [Raymarine SeaTalkNG \(STNG\)](#) connectors.

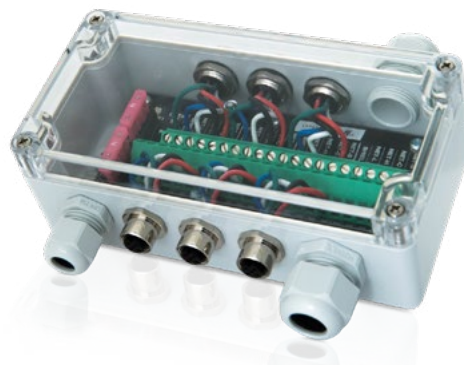
As STNG uses exactly the same data as NMEA 2000 but chooses not to use the DeviceNet standard for its connector system, adapter cables are needed to change the connector type when installing STNG devices on NMEA 2000 networks, or vice versa.

STNG cables can be stripped back and wired directly to the terminals inside either variant of the QNB-1, which means that you can mix and match STNG with DeviceNet. The wiring colours inside STNG cables are the same as DeviceNet cables.

Removing the connectors from the PMW variant is not advised as the QNB-1 will lose its watertight integrity. Instead, we recommend simply connecting an STNG backbone cable through one or both of the backbone glands to enable the mix & matching options described above.

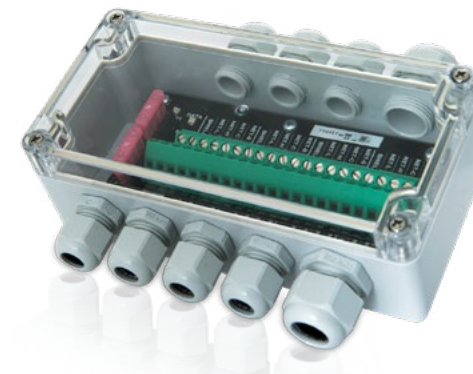
Panel Mounted Wire connector option (PMW)

The PMW option is the simplest to install as all the connectors are pre-wired and provide plug & play connectivity. The backbone should always be installed through the glands provided that are furthest from the power insertion point.



Glanded option

A glanded option of the QNB is available for more customised installations using Actisense bulk cable. A rubber, self-tightening seal inside each gland clamps around the cable when it is installed and the screw is tightened.



11. Basics of Diagnosing a Network



NMEA 2000 Networks and the devices on them do not always work, and issues can arise when implementing more instruments into a complex network. The following pages will detail steps that can be taken to help fault finding on the network.

Testing Power Supply and Termination Resistors

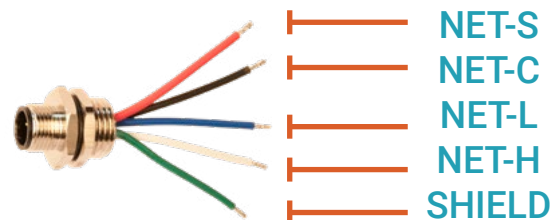
Ideally, the power supplied to the network should be tested at 2 points; the insertion point, and the extremities of the network.

Power insertion point should be tested to determine how much power is actually being supplied to the network. Any device which does not have an external power supply is powered from the backbone, thus there needs to be sufficient power to run all of the connected instruments. The power should never exceed 14V, and be below 9V.

With network devices using up some of the supplied power and impedance from cabling also dropping the voltage, it is important to know that the voltage at the end of each backbone leg is adequate. Temporarily remove a termination resistor from the end of the network and use a voltmeter to measure across the NET-S and NET-C pins. The measured value should be at least 9V. The diagrams below will help you find these pins when using Actisense connectors.



An Actisense Panel Mounted Wire (PMW) connector is a great tool for plugging in to a spare T-piece to quickly identify the correct pins via the wiring colours. It is recommended that each wire from the PMW is terminated inside a terminal block prior to plugging it in to the network as voltage may be present across the NET-S and NET-C pins



Diagnostics Continued...



When testing the resistance on the network, the value expected is 60 ohms. This test can be performed by powering down the network and placing a DMM across the NET-H and NET-L pins.

If 120 Ohms is measured, only one termination resistor is installed. A second resistor will need to be installed at the opposite end of the network to the one that is already present.

If 40 Ohms is observed, there are 3 termination resistors installed on the network so 1 will need to be removed. If it's not obvious where the third resistor is, check for any devices on the network with installed termination resistors and ensure they are switched off.

Network devices with termination resistors installed do not achieve NMEA 2000 certification as this practice can cause confusion on the network.

Further Testing

If the issue is still present after verifying that both the power supply and termination resistance are good, then further testing is required: A common technique used for investigating a network is to split the network into sections by moving the terminator:

Disconnect one half of the backbone and move the termination resistor to the new, temporary end of the network. If the issue remains you have narrowed it down to the half of the network that is still powered and active.

If the issue does not remain it is in the half of the network that has been disconnected. Keep performing this half split method until you are able to narrow it down to a single device, if possible. **Don't forget to move the termination resistor each time to ensure the network is correctly terminated.**

Once the issue has been narrowed down, try swapping out t-pieces or cabling with ones that are known to be good. If Field Fit Connectors have been used, check the wiring connections inside to ensure that they are correct and firmly secured in place.

If possible, check the wiring inside the device is properly and securely terminated, ensuring to observe anti-static precautions if exposing internal electronics. It is always best to check that this is ok with the device manufacturer before performing this step to ensure you do not void any warranty.

If an issue still remains you now know there is a problem with the device and it's time to contact the manufacturer of that device.

Diagnostics Continued...



Checking availability and accuracy of data on the network

The easiest way to check for NMEA 2000 PGNs on a Network is to use the [Actisense NGT-1 NMEA 2000 to PC Interface](#) device, in combination with [Actisense NMEA Reader](#). Our NGT-1 is capable of understanding every PGN currently available in the NMEA 2000 specification, meaning there is no PGN present on the bus that the NGT-1 cannot read and transfer to NMEA Reader.

NMEA Reader can be used to display the data currently on the network in a user friendly format, where each field within a PGN is decoded and displayed in a human readable character format, allowing for easy identification of problems and invalid values.

The screenshot shows the NMEA Reader software interface. The main window displays a table of network data with columns for Line, PGN, SRC, DST, Name, Time, Interval, and Data. The selected PGN is 130577, which is 'Direction Data'. The detailed view on the right shows the decoded fields for this PGN:

Line	PGN	SRC	DST	Name	Time	Interval	Data
1	126998	0	255	Configuration Information	17:09:35:004		02 01 02 01 45 01 41 63 ...
2	126996	0	255	Product Information	17:09:34:875		34 08 69 2C 4E 4D 45 41 ...
3	60928	0	255	ISO Address Claim	17:09:32:625		97 B3 22 22 00 87 32 C0
4	126993	0	255	Heartbeat	17:10:06:258		60 EA EB CC FF FF FF FF
5	130577	1	255	Direction Data	17:10:22:756	0.49	DF EA 5A 8E 9E 03 5A 8E ...
6	130312	1	255	Temperature - DEPRECATED	17:10:23:335	2.00	04 00 00 FB 72 FF FF FF
7	130311	1	255	Environmental Parameters - DEPRECATED	17:10:23:374	0.50	08 C0 FB 72 FF 7F FF FF
8	130310	1	255	Environmental Parameters - DEPRECATED	17:10:23:102	0.50	F8 FB 72 FF FF FF FF

The detailed view on the right shows the following fields:

- Field 1: Data Mode = 15 (Data not available)
- Field 2: Set/COG/Heading Ref. = 1 (Direction Reference Magnetic)
- Field 3: Reserved field
- Field 4: Sequence ID = 234
- Field 5: Course Over Ground = 3.6442 Radians (208.797 Degrees)
- Field 6: Speed Over Ground = 9.26 Metre Per Second (18.00 Knots)
- Field 7: Heading = 3.6442 Radians (208.797 Degrees)
- Field 8: Speed through Water = 31.38 Metre Per Second (61.00 Knots)
- Field 9: Set = Data not available
- Field 10: Drift = Data not available

Download the NMEA Reader for free, click here:

[Download NMEA Reader](#)

12. Other Useful Products

Other useful products for a robust and reliable NMEA 2000 network that you can rely on:

NMEA 2000 4-Way Drop (A2K-4WD)

Reach up to four devices with a single cable. The 4-way drop makes it possible to shorten the length of each cable needed before reaching a T-piece. Reducing your NMEA 2000 cabling requirements.



Lite Gender Changer Cables (A2K-GCF-0M25 / A2K-GCM-0M25)

In the scenario where there are two connectors of the same gender on a network, the Gender Changer cable can be placed between the two, allowing them to be connected together. These are available in both Male and Female versions.



NMEA 2000 Smart Starter Kit 4 (A2K-KIT-4a)

- **A2K-MPT-2:** Micro Power T-piece - Contains a twin pair of power cables for even power distribution across the NMEA 2000 network.
- **A2K-T-MFF:** 2 x T-pieces - for extending the network from the power T-piece and connecting NMEA 2000 devices to the network.
- **A2K-TER-U:** 2 x Smart Universal Micro Terminators - To terminate your NMEA 2000 network and easily diagnose any power or voltage issues.
- **A2K-TDC-4M:** 1 x 4 metre cable - for extending the length of the backbone if needed or to connect an NMEA 2000 device to a T-piece.

The NMEA 2000 Starter Kits from Actisense provides everything that is required to start an NMEA 2000 installation. View the rest of our starter kits on the next page.



13. Actisense Starter Kits



A2K-KIT-1a NMEA 2000 Starter Kit

- **A2K-MPT-2:** Micro Power T-piece - Contains a twin pair of power cables for even power distribution across the NMEA 2000 network.
- **A2K-T-MFF:** 2 x T-pieces - for extending the network from the power T-piece and connecting NMEA 2000 devices to the network.
- **A2K-TER-M / F:** 2 x termination resistors - To maintain signal integrity.
- **A2K-TDC-2M:** 1 x 2 metre cable - for extending the length of the backbone if needed or to connect an NMEA 2000 device to a T-piece.



A2K-KIT-2a NMEA 2000 Starter Kit

- **A2K-MPT-2:** Power T-piece - Contains a twin pair of power cables for even power distribution across the NMEA 2000 network.
- **A2K-T-MFF:** 2 x T-pieces - for extending the network from the power T-piece and connecting NMEA 2000 devices to the network.
- **A2K-TER-M / F:** 2 x termination resistors - To maintain signal integrity.
- **A2K-TDC-6M:** 1x 6 metre cable - for extending the length of the backbone if needed or to connect an NMEA 2000 device to a T-piece.

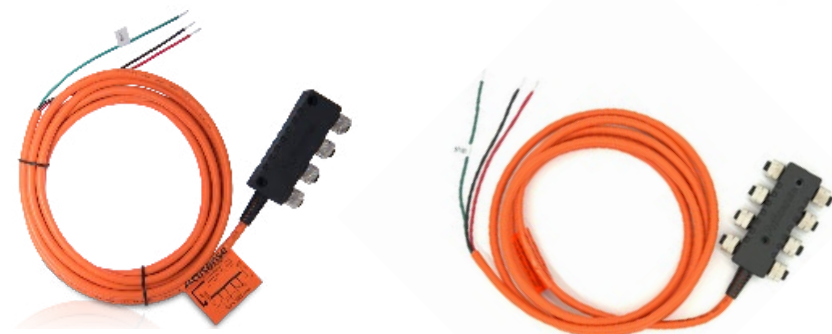
A2K-KIT-3 NMEA 2000 Starter Kit

- **A2K-4WT:** 1 x 4-way T-piece - providing instrument drops for up to 3 devices (one port is used for power).
- **A2K-MPC-1:** 1 x Micro power cord - can be plugged straight in to any available port on the 4-way T-piece to provide network power.
- **A2K-TER-M / F:** 2 x Termination resistors - To maintain signal integrity.



A2K-SBN-1 / A2K-SBN-2 (Self-contained Boat Network)

- Space for 4 (SBN-1) or 8 (SBN-2) instrument drops.
- Over moulded power cord attached.
- 2x Termination resistors built in.



14. Useful NMEA Resources

Need further support with your NMEA 2000 Network? Here is a directory of useful contacts:



National Marine Electronics Association

Email: info@nmea.org

Tel: 410-975-9425

Website: www.nmea.org

Actisense[®]

Actisense (Active Research Ltd)

Technical Support: support@actisense.com

Stock availability & distributor enquiries: sales@actisense.com

Tel: +44 (0) 1202 746682

Website: www.actisense.com

Visit our extensive Knowledge Base for frequently asked question - www.actisense.com/knowledge-base

View the complete directory of NMEA 2000 certified products:

**NMEA Certified
Products**