The Ultimate Guide to NMEA 2000® Networking
Contents

1. What is NMEA 2000?
   - Who are the NMEA?
   - What is NMEA 2000?
   - The Network That CAN
   - DeviceNet
   - Certification

2. Why use NMEA 2000?
   - What is the difference between NMEA 2000 and NMEA 0183?
   - What are the advantages of NMEA 2000?

3. Minimum Network Requirements
   - Minimum Network Requirements
   - Common Phrases

4. NMEA 2000 Cable Limitations

5. Network Power
   - Power T-Piece
   - Micro Power Cable
   - Small Boat Network
   - Quick Network Block

6. T-Pieces and Terminators
   - Micro T-Pieces
   - Micro 4-Way T-Pieces
   - Terminating Resistors
   - Smart Universal Micro Terminator

7. Drop Cables and Backbone Extension
   - Trunk and Drop Cable
   - Bulk Cable

8. Field Fit Connectors
   - Field Fit Connectors

9. Steps to Field Fit Connector Success

10. The Quick Network Block
    - At a Glance
    - Detailed Overview
    - Raymarine SeaTalkNG Solution
    - Glanded option

11. Basics of Diagnosing a Network
    - Adequate Power Supply & Termination Resistance
    - Digging Deeper
    - Checking availability and accuracy of data on the network

12. Other Useful Products
    - NMEA 2000 4-Way Drop
    - Lite Gender Changer Cables
    - NMEA 2000 Smart Starter Kit 4

13. Actisense Starter Kits
    - A2K Starter Kits
    - Self-contained Boat Network 1 / 2

14. Useful NMEA Resources
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. 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.
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 network’s 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.
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:

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

*AWG = American Wire Gauge*
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.

![Actisense Power T-Piece Wiring Diagram](image)

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

1. Prepare the connector by removing any connectors or covers, leaving the wires exposed.
2. Connect the wires to the corresponding ports on the connector. The color codes for the wires are:
   - NET-S (red)
   - NET-L (blue)
   - Shield (green/bare)
   - NET-H (white)
   - NET-C (black)
3. Secure the wires to the connector with appropriate fasteners, ensuring they are correctly aligned.
4. Ensure all connections are tight and secure to prevent any松动 or damage.
5. Test the connection to verify its functionality and reliability.

Follow these steps carefully to achieve a successful Field Fit Connector connection.
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.

<table>
<thead>
<tr>
<th>Wire Colour</th>
<th>Connects to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>NET-S</td>
</tr>
<tr>
<td>Black</td>
<td>NET-C</td>
</tr>
<tr>
<td>White</td>
<td>NET-H</td>
</tr>
<tr>
<td>Blue</td>
<td>NET-L</td>
</tr>
<tr>
<td>Bare/green</td>
<td>Shield</td>
</tr>
</tbody>
</table>

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

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.

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

Blanking Plugs: Purchasable via Dealer / Distributor.
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 it’s 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 ganged 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.
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.
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.
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.

Download the NMEA Reader for free, click here:
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 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:** 1 x 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](http://www.nmea.org)

**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](http://www.actisense.com)

View the complete directory of NMEA 2000 certified products: