How-To

Stay Connected

NMEA 2000 Networks

By Jack and Alex Wilken

We live in the age of connectivity and that has certainly become a part of marine electronics. There was a time we went cruising with only a plastic sextant and depth sounder. Now, with the flip of a switch, you have the possibility of knowing your position, the position of other vessels (without the use of radar), the tides, and a list of other things that would go on over the horizon if we continued. The icing on the cake is that it can all be wireless. There was a time when you might put repeaters for some instruments at the chart table or in a cabin, but now you can have it anywhere you have an IPad or tablet - even up on the foredeck. Of course, there is a balance between having more information about more aspects of your boat and surroundings and looking at a display instead of looking where you are going.

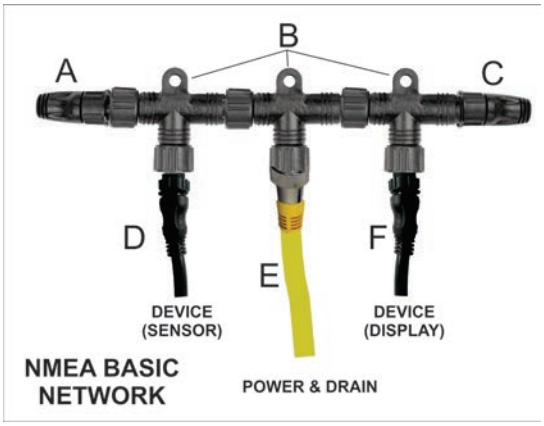


Figure 1: This is a basic system: "A" is a male terminator. "B" are (3) backbone tees. The center one is the power tap. The left tee is connected to a device, a sensor in this example, via "D", a drop cable. The drop cable "F" goes to the other devise in the network - probably a display. The terminator "C" is female because the tees are the opposite gender at both ends of the backbone side of the tee. Backbone and drop cables also have gender opposite ends. If you want to separate the tees, insert a backbone cable.

The National Marine Electronics Association (NMEA) began in 1957. In the early 80s, NMEA created a uniform interface standard to allow electronics from different manufacturers to talk to each other; that was NMEA 0183 and its predecessors. This has been followed by NMEA 2000 (N2K) which is the standard today. This standard is the subject of this month's article.

Before we complicate what can be a very simple network installation on many small boats, let's give a few basic guidelines. A network can be as simple as one display and a sensor. That could look like (2) backbone tees, (2) terminators, (1) power tap tee, (2) drop cables of less than 6m of length, and (1) power cable (Figure 1). This is not only a simple network, but it is simple to add devices to it - just add (1) backbone tee and (1) drop cable per device and you are set. One thing to remember is that the drop cable and the device always connect to the top of the tee unless there is a special terminator fitting involved. You can keep going like this for a while, but after 3 or 4 devices you need to analyze the network before you continue going forward. What follows is to aid you in that pursuit. (You will notice that the lengths are all given in meters rather than feet. Voltage drop calculations will be made easier by this.)

The central player in any larger system is the multi-function display as most everything else should be able to be displayed on it via N2K. There are exceptions, and the most obvious are radar or sonar. You used to buy things like a depth sounder or boat speed indicator, etc., but now you can buy a sensor and the information will display on your multi-function display.

There are three different sizes of cables used in the N2K network: Mini, Mid, and Micro. The smallest, Micro, is the most common, coming with most electronics you will buy. There are guidelines for the lengths of cables. The length of combined cables and connectors between electrical devices and terminators must not be more than 250m for Mini or Mid cables, or 100m for Micro cables. This can be measured from one terminator to the other, or to the last device if that is farther from the last backbone tee (Figure 2, page 47). You need to add up all the length of your drop cables and make sure that the number is less than 78m; also, no one of them can be longer than 6m. You cannot daisy chain devices off a drop cable, but you can use a multi-port box or multi-tap tee to avoid more tees and drop cables. The maximum number of devices on a N2K network is 50.

The power can be connected to the network with a tee at either end of the backbone, referred to as an unbalanced system, or in the middle, known as a balanced system. Small networks will not suffer much voltage drop from being unbalanced, but a network with lots of devices should be balanced. You can calculate the voltage drop with this formula: E (voltage drop) = 0.1 x LEN (explained below) x L x 0.057 (Micro) or 0.016 (Mid / Mini)

If the drop is less than 1.5v, you can use an unbalanced system. If the drop is 1.5v to 3v, the power tap

NMEA 2000 CABLE TYPE RULES

Max Length	Amp Capacity	Power AWG	Connectors	Maximum Devices	LEN (Load Equivalent Number)	Max Drop Length
250 Meters	8 Amps	15 AWG	Mini	50	160	6 meters
250 Meters	4 Amps	16 AWG	Mid	50	80	6 meters
100 Meters	4 Amps	22 AWG	Micro	50	80	6 meters
Maximum total length of Drop Cables= 78 meters						

Figure 3: These rules will keep you safe.

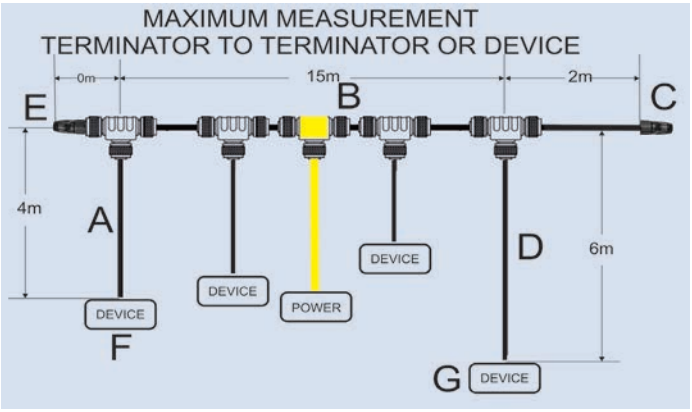
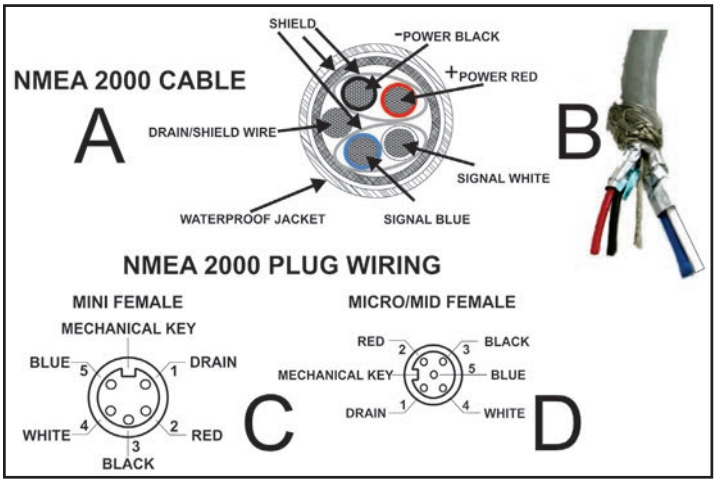


Figure 2: Maximum measurement of terminator to terminator or devices: Measure the length of the backbone plus the distance to the last device at each end of the network, or, to the terminator if it is farther from the end tee than the device. In this case, terminator "E" is mounted directly on the left backbone tee. The 4m drop cable "A" is therefore longer, and drop cable "D" with device "G" is longer than the 2m backbone between the right tee and terminator "C". The sum of 4m + 15m + 6m= 25m which is well below the maximum.

Figure 4: Cables and plugs: "A" is a cross section of a NMEA 2000 cable, and "B" is an image of that cable. "C" is a Mini Female plug schematic showing wire color and the numbers that are displayed on the plug. "D" is a Micro Mid Female plug.



should be as close as possible to the middle of the network. The 'middle', or balanced system in this case, does not mean an equal number of devices on each side of the power tap. It means the sum of the LEN numbers and the length of the cables, then divided by 2. LEN = Load Equivalent Number, and one LEN = 50mA. The LEN number should be printed on the device and in the manufacturer's documentation. There is a maximum LEN for cable types (Figure 3, page 46). The power cable must be fused at 3 Amps for Micro and 8 Amps for Mid and Mini cables. It is possible to mix cable types and sizes, but this may require plug adapters. The power wires in the Mid and Mini cables are bigger than the Micro cables, and, therefore, have less resistance, so less voltage drop. This can be a solution if your calculation comes out over 1.5v. Also, you can add a second or third power tap as long as you do not violate any grounding or shielding rules. That rule is one ground point and one shield wire connection to that point. At this address online you will find free software called N2K Builder that will enable you to build a virtual network to give you confidence that your design works before you start buying cables and fitting: http://www.maretron.com/support/n2kb_downloadform.php

Electrically there is no mystery with N2K systems - the cables include five wires with a shield (drain or screen) within a single waterproof jacket. These 5 wires are as follows: two signal wires, the power wires (the ground, known as the negative, and the positive), and a shield wire (Figure 4). The shield is to keep external Radio Frequency (RF) interference away from the signal wires and reduces RF from radiating out from the N2K network. Some manufacturers have their own version of N2K; this gives them the possibility to make some of their legacy gear compatible with new gear

while still being N2K compliant. An example of this is SeaTalk NG cables which may have a 6th wire so they may communicate with SeaTalk1, which is similar to 0183. The SeaTalk NG cable's locking collar is on the device, resulting in a smaller diameter and a better ability to pass through tight places.

We recommend that you treat the power input for the network as a critical load and use a wire size with 3% or less voltage drop. In order to maintain sufficient voltage in the network, you need to start out with as high as possible voltage at the power injection point in the network. If you are running this wire to a switch out in the cockpit and back to a Micro backbone, this could easily mean 12 AWG wire if the total circuit to the source is 50'. It might be better to keep the wire run as short as possible by putting a relay in the circuit if you need to control it from a remote location. As we wrote above, the network will work if there is no more than 1.5 volts difference between any two devices. As the network grows in the number of devices, move the power tap to the center of the backbone load. For this reason, sailboats present a special situation as the mast length is as long as or longer than the entire boat. This means mounting a N2K compatible wind sensor at the top of the mast would break the 6m (20') drop cable rule. The answer is to run a backbone cable up the mast and use an inline terminator which allows you to connect directly on the end of the backbone, terminating the backbone at that point. This means the power tap should probably be somewhere close to the base of the mast with the long cable run - this is a good use of low resistance Mid/Mini cable - and the LEN of the sensor being one side of the network and the rest of the devices and cables being the other. You would calculate both sides of the network and move the power tap accordingly - especially as you add devices.

Your network must only be grounded at one place in your electrical system; this should be the negative of your supply voltage which is also where the shield/drain will connect. That means the shield wire only connects at this one place.

There are some cool new sensors waiting for you at your local chandlery. Some examples: 1.) A wind speed/wind direction/air temp/humidity mast head sensor with no moving parts. 2.) A boat speed/depth/water temp all-in-one thru hull fitting. 3.) An ultrasonic boat speed sensor with a tenth-of-a-knot accuracy and no paddle wheel or other moving parts.

Some multi-function displays may have input connections for both NMEA 0183 and 2000. Usually this means that the signals will be converted to N2K, but not necessarily the other direction. There are also various NMEA 0183 to 2000 bridges or converters that can, for instance, give an older auto pilot a second chance, and also PC interfaces that allow you to monitor all the data on the network for diagnostic purposes.

This sounds complicated, and it is, but 90% of small boat installations only require the simple installation from paragraph two. Give that a second read. You can do it!

Jack and Alex Wilken are experienced boat builders and have cruised extensively. They each hold a 100-ton USCG Captain's License and are the owners of Seattle Boat Works LLC in Seattle.