# NMEA 2000 Network Fundamentals

A NMEA 2000 network is made of connected NMEA 2000 devices that communicate using basic plug-and-play connectivity.

This guide provides descriptions of the NMEA 2000 connectors and cables sold by Garmin, and the fundamental concepts of installing a NMEA 2000 network on your boat. If you experience difficulty installing a NMEA 2000 network, contact Garmin Product Support or a certified NMEA 2000 technician. In the USA, contact Garmin Product Support by phone: (913) 397-8200 or (800) 800-1020 or go to www.garmin.com/support/. In Europe, contact Garmin (Europe) Ltd. at +44 (0) 870.8501241 (outside the UK) or 0808 2380000 (within the UK).

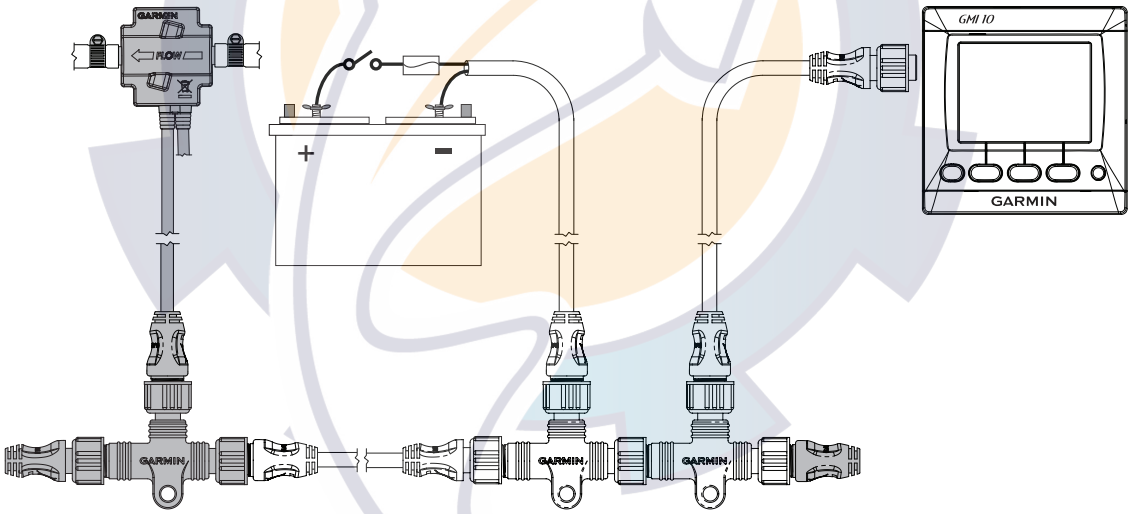
If your boat already contains a NMEA 2000 network and you would like to add Garmin NMEA 2000 components, see page 8.

For a glossary of commonly used NMEA 2000 terms, see page 8.

After you have installed your NMEA 2000 network, use the checklist on page 9 to verify the installation.

## Garmin NMEA 2000 Devices and Components:

Garmin uses NMEA 2000 micro connectors on units, sensors, and T-connectors that follow the NMEA 2000 standard and are compatible with other NMEA 2000 micro connectors, cables, and NMEA 2000-compatible devices. Garmin sensors are commonly packaged with a drop cable, a T-connector, and two terminators. Garmin displays may also include additional NMEA 2000 components (such as a power cable). The NMEA 2000 components included with a Garmin sensor or display are listed in the product documentation. A diagram on the product box shows which NMEA 2000 components are included.

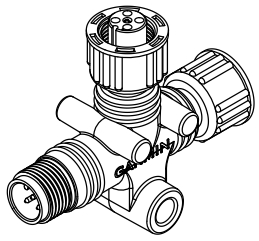
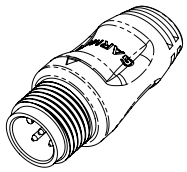
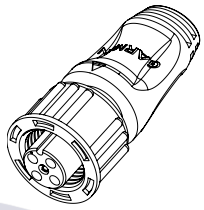
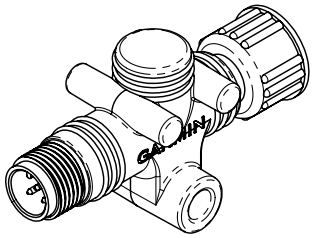


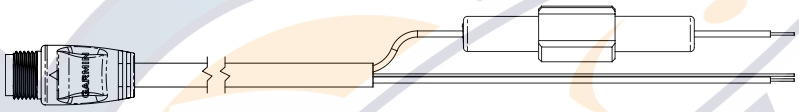

**Sample Box Diagram (GFS 10)**

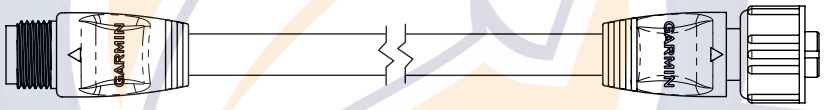
In the sample box diagram, a complete NMEA 2000 network is shown, and the parts included with the sensor are shaded. In this example, a T-connector and two terminators are included with a Garmin GFS 10 fuel sensor. A NMEA 2000 power cable, an additional drop/backbone cable, and additional T-connectors are not included with a GFS 10 fuel sensor. The GFS 10 fuel sensor, as shown by the shaded components on the box diagram, is intended to be connected to an existing NMEA 2000 network on your boat. If you do not have a NMEA 2000 network on your boat, this guide will help you assemble one.

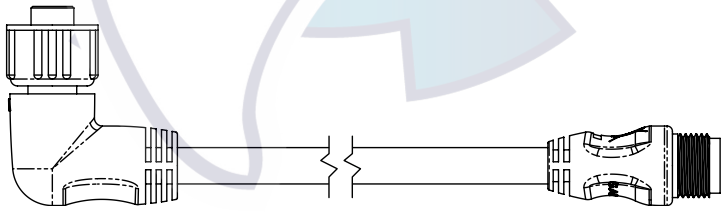
## NMEA 2000 Components

The main components of a NMEA 2000 network are T-connectors, terminators, backbone/drop cables, and a power cable.

| T-connector | Male Terminator | Female Terminator | In-line Terminator |
|---|---|---|---|
|  |  |  |  |
| 010-11078-00 (Garmin part number) | 010-11080-00 | 010-11081-00 | 010-11096-00 |

| Power Cable |
|---|
|  |
| 010-11079-00 (2 Meters [6.5 feet]) (3 A fuse included) |

| Backbone/Drop Cable | |
|---|---|
|  | |
| 305 Millimeters (1 foot) | 010-11076-03 |
| 2 Meters (6.5 feet) | 010-11076-00 |
| 6 Meters (20 feet) | 010-11076-01 |
| 10 Meters (33 feet) (Backbone only) | 010-11076-02 |

| Specialty Cable/Connectors | |
|---|---|
|  | |
| Right Angle Drop Cable, 2 Meters (6.5 feet) | 010-11089-00 |
| Field-Installable Connector - Male* | 010-11094-00 |
| Field-Installable Connector - Female* | 010-11095-00 |
| NMEA 2000 Network Power Switch | K00-00368-00 |

*The field-installable connectors are used to create custom-length drop cables and custom-length backbone extension cables. The field-installable connectors can be used to shorten any Garmin NMEA 2000 drop/backbone cable.

**NOTE:** All male/female connections are interchangeable. Ensure that the T-connectors are used properly when constructing your NMEA 2000 network. See page 4.

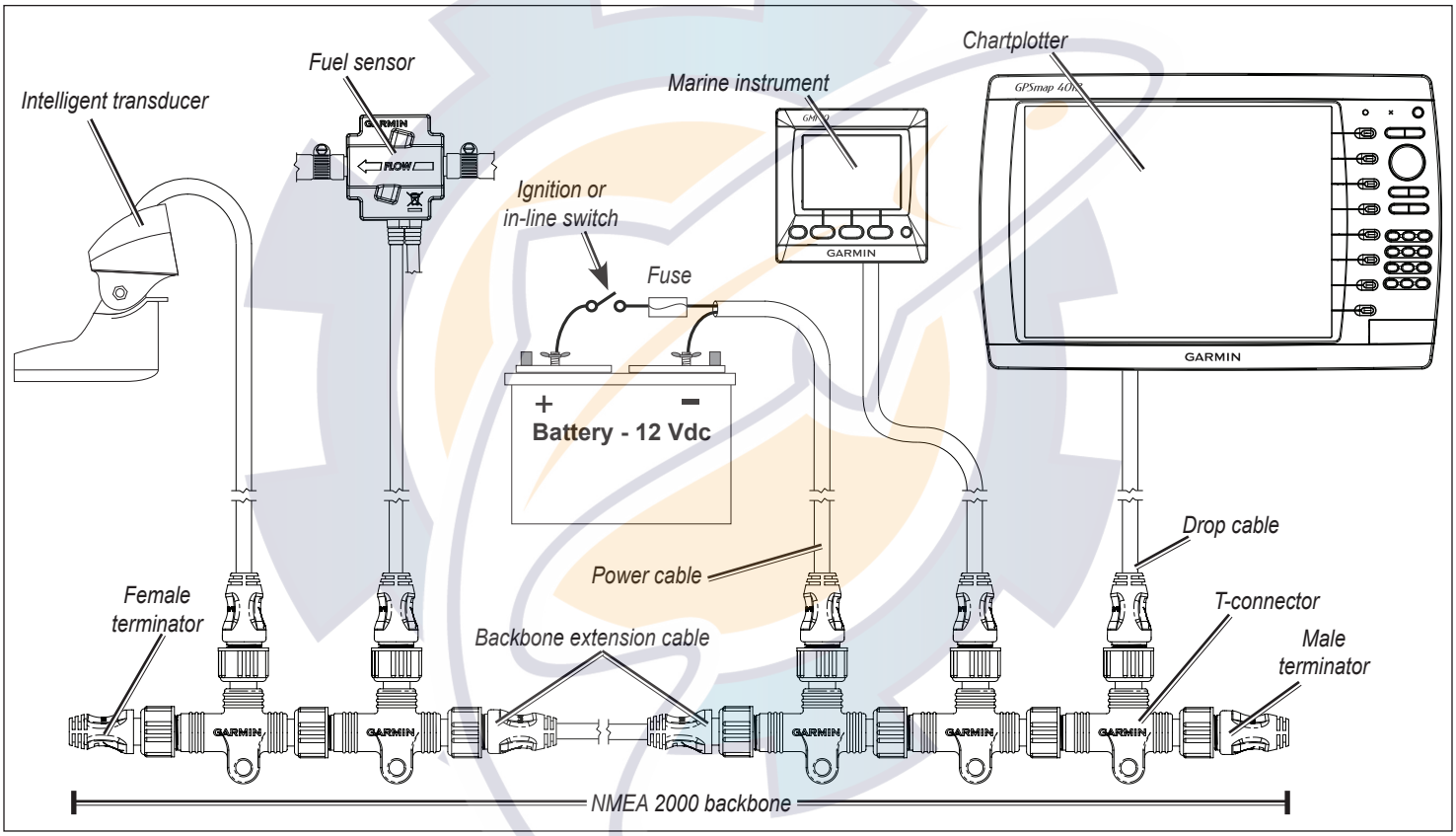
## Building a NMEA 2000 Network

The main communication channel of a NMEA 2000 network is a backbone to which your NMEA 2000 devices connect. Each NMEA 2000 device connects to the backbone with a T-connector. The NMEA 2000 backbone must be connected to power, and terminators must be installed at both ends for the network to function correctly.

When you design a NMEA 2000 network, start by creating a diagram of the network. This diagram will include important information such as:

- The devices you intend to connect to your network
- The approximate location of the backbone and devices on your boat
- Approximate distances between devices and the backbone, as well as the overall length of the backbone
- Power consumption of each device (Load Equivalency Number)

**Sample NMEA 2000 Network**




**NOTE:** This diagram illustrates the NMEA 2000 data connections to each device or sensor. Some devices or sensors can be powered by the NMEA 2000 network; others may require a separate power connection. Consult the installation instructions for each device you connect to your NMEA 2000 network to be sure you supply power to the device appropriately.

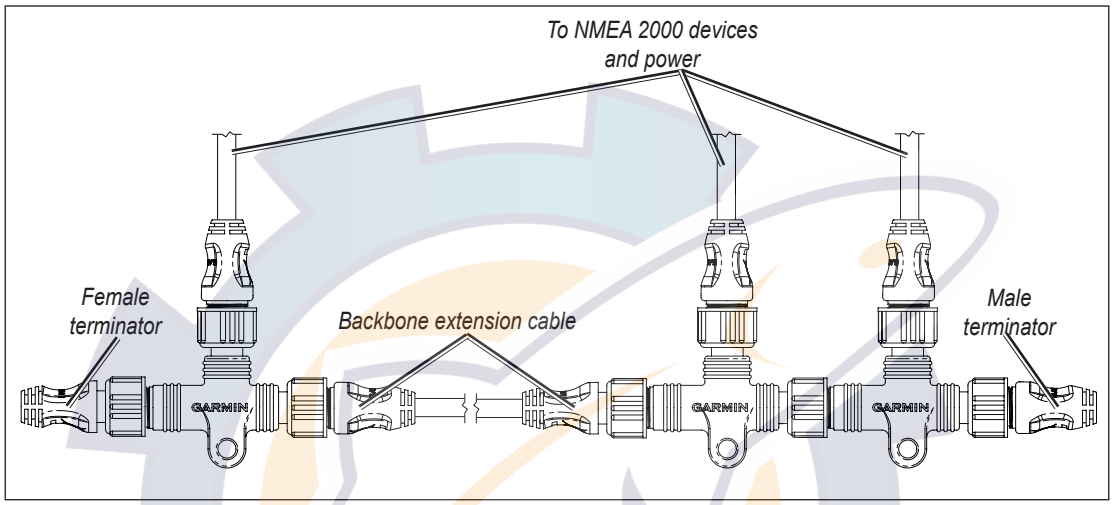
When building a NMEA 2000 network, you must follow certain rules to make sure your NMEA 2000 network functions correctly. Be sure to understand the following concepts:

- Linear backbone construction (page 4)
- Power connection and distribution (page 5)
- Proper termination (page 7)
- Cable length and device limits (page 8)

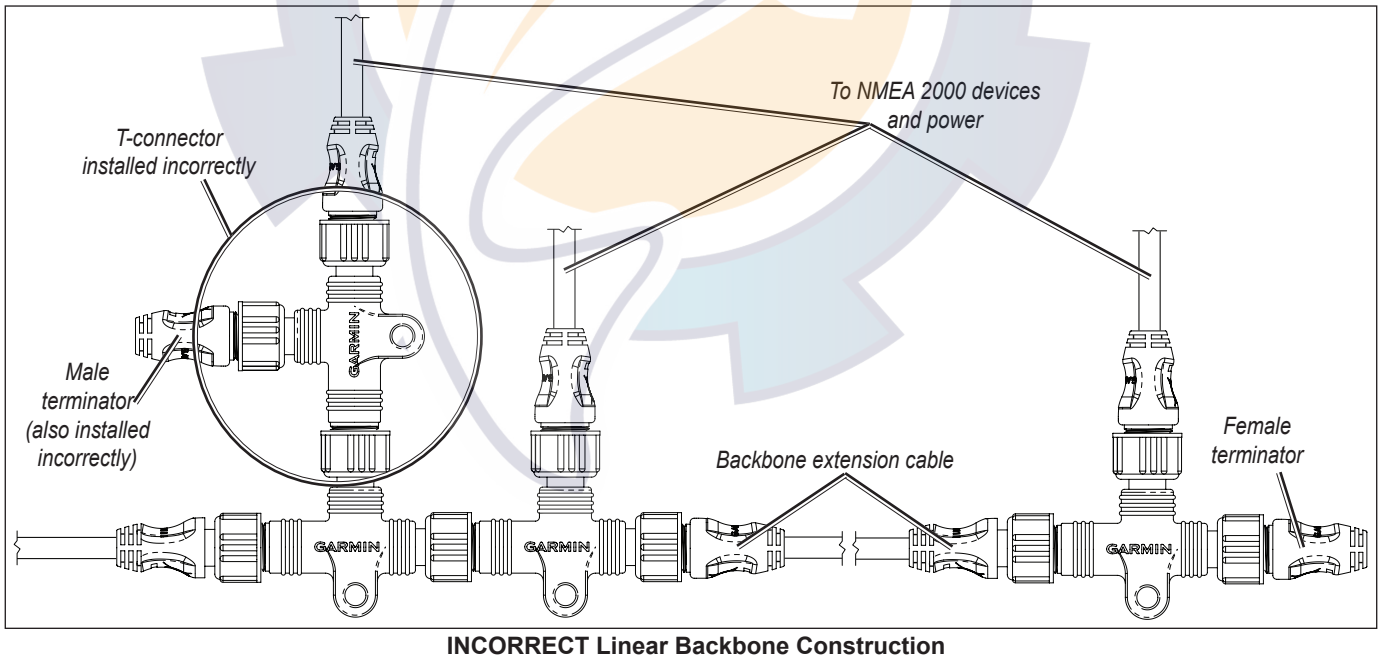
## Linear Backbone Construction

Use the NMEA 2000 T-connectors to construct your NMEA 2000 backbone, and extend the backbone with appropriate lengths of backbone cable if necessary. Use one T-connector per device. Use the sides of the T-connector to construct the backbone of the NMEA 2000 network, and use the top of the T-connector to attach a NMEA 2000 device. By using only the sides of the T-connectors to construct the backbone, you create a linear construction to your NMEA 2000 network. T-connectors can be separated by backbone cable or connected directly together

Although the male and female connectors on the T-connectors and backbone cables will fit on all sides of a T-connector, it is very important to use only the top of the T-connector to attach NMEA 2000 devices, not to attach other T-connectors or backbone cables.




**CORRECT Linear Backbone Construction**




**INCORRECT Linear Backbone Construction**

## Power Connection and Distribution

Your NMEA 2000 network must be connected to a 12 Vdc power supply. Do not connect your NMEA 2000 network to any other voltage source, such as a 24 Vdc power supply. Use a NMEA 2000 power cable to connect your NMEA 2000 backbone to the auxiliary power switch on your boat. If you do not have an auxiliary power switch, or if connecting to the auxiliary power switch causes electrical interference, connect the NMEA 2000 power cable directly to the battery and install an in-line switch.

**CAUTION:** If you connect the NMEA 2000 network to your battery without an in-line switch, it may drain your battery.

Be sure to ground the NMEA 2000 power cable. Ground the drain wire (bare) to the same location as the ground wire.

The Garmin NMEA 2000 power cable connects to a T-connector like other drop cables. Make sure to connect the NMEA 2000 power cable to the top of a T-connector; never connect the NMEA 2000 power cable to the side of a T-connector. You can connect power either at the end of your NMEA 2000 network or in the middle. When planning where to place the power cable and T-connector on your NMEA 2000 network, you will need to evaluate how the NMEA 2000 devices connected to your network use power. The NMEA 2000 network will work properly as long as there is no more than a 3 Vdc drop in the supply voltage between the power source and the NMEA 2000 device located farthest from the power source on the NMEA 2000 network. To determine the voltage drop in your NMEA 2000 network, use this equation:

**Voltage Drop = Cable resistance (ohms/m)* × Distance (from the battery to the farthest device, in meters) × Network Load** × 0.1**

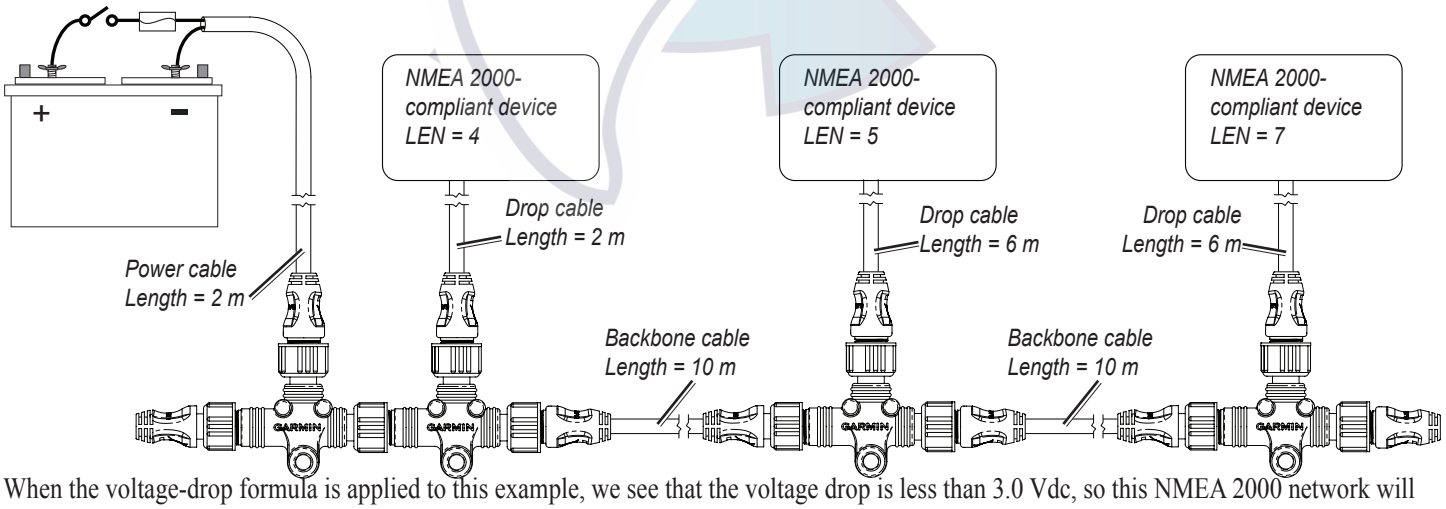
**Garmin cable resistance value = 0.053*
***Network Load = the sum of Load Equivalent Numbers (LEN) between the battery and the end of the network. The LEN for each device should be visible on the device, or provided in the documentation for the device.*

- If you calculate a voltage drop of 3.0 Vdc or less, then you can connect power to either the end or the middle of your NMEA 2000 network, and it will function correctly.
- If you calculate a voltage drop of more than 3.0 Vdc, you must connect power to the middle of your NMEA 2000 network. The location will depend on the network load and distance from the battery. Try to balance the voltage drop equally on both sides of the power connection.
- If a voltage drop of under 3.0 Vdc is not possible on your NMEA 2000 network, contact a professional installer

### Examples

The following examples show a correctly designed, end-powered NMEA 2000 network; an incorrectly designed NMEA 2000 network; and a redesign of the incorrectly designed NMEA 2000 network to correctly balance power on the network.

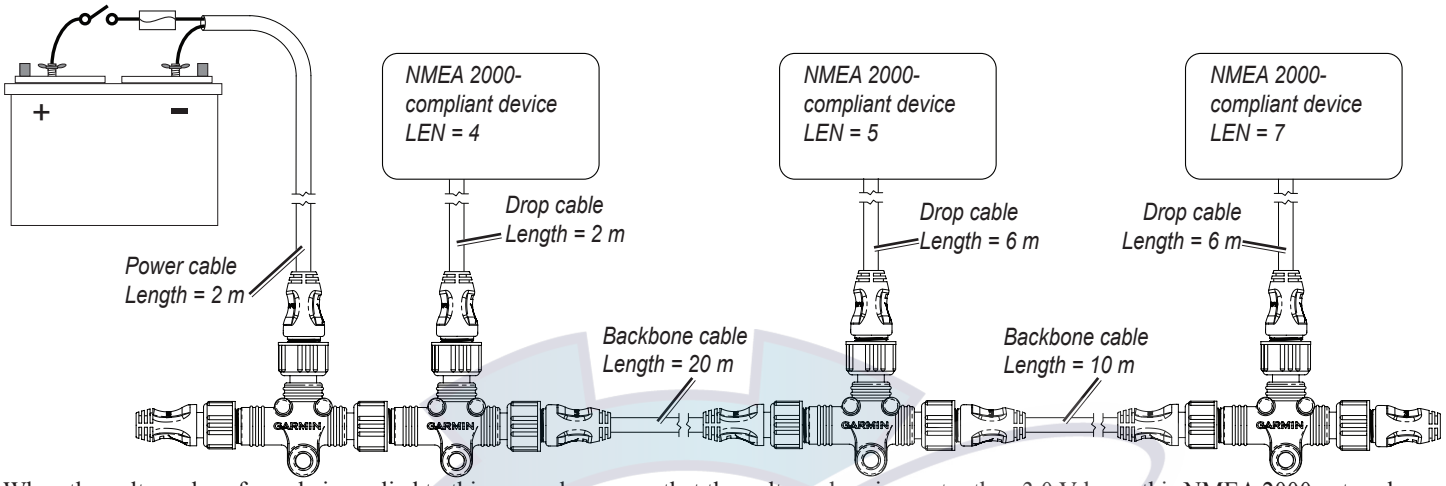
**End-powered NMEA 2000 network, correctly designed:**




When the voltage-drop formula is applied to this example, we see that the voltage drop is less than 3.0 Vdc, so this NMEA 2000 network will function correctly when powered at the end.

**Voltage Drop = 0.053 × (2 + 10 + 10 + 6) × (4 + 5 + 7) × 0.1 = 2.37 Vdc**
*Cable resistance* *Distance* *Network load*

**End-powered NMEA 2000 network, incorrectly designed:**

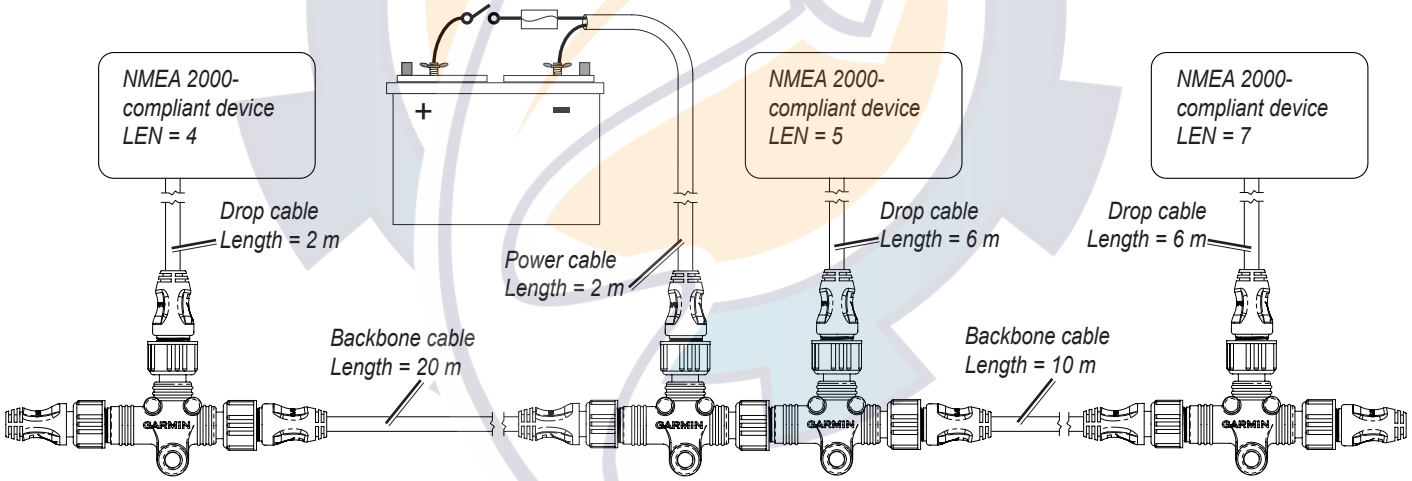



When the voltage drop formula is applied to this example, we see that the voltage drop is greater than 3.0 Vdc, so this NMEA 2000 network will not function correctly when powered at the end.

$$\text{Voltage Drop} = \underset{\text{Cable resistance}}{0.053} \times \underset{\text{Distance}}{(2 + 20 + 10 + 6)} \times \underset{\text{Network load}}{(4 + 5 + 7)} \times 0.1 = 3.22 \text{ Vdc}$$

This NMEA 2000 network must be redesigned with the power connected to the center of the network in order to function correctly.

**Middle-powered NMEA 2000 network, correctly designed:**




When the NMEA 2000 network is redesigned with the power source in the center, you calculate the voltage drop in both directions. If the T-connector to which you connect the power source is connected directly to another T-connector (as shown in this example), use the LEN from that device as part of the calculation for both directions.

When the voltage drop formula is applied to both the left and right sides of the power source in this example, we see that the voltage drop is less than 3.0 Vdc on each side, so the NMEA 2000 network will function correctly.

$$\text{Voltage Drop Left} = \underset{\text{Cable resistance}}{0.053} \times \underset{\text{Distance}}{(2 + 20 + 2)} \times \underset{\text{Network load}}{(4 + 5)} \times 0.1 = 1.145 \text{ Vdc}$$

$$\text{Voltage Drop Right} = 0.053 \times (2 + 10 + 6) \times (5 + 7) \times 0.1 = 1.145 \text{ Vdc}$$

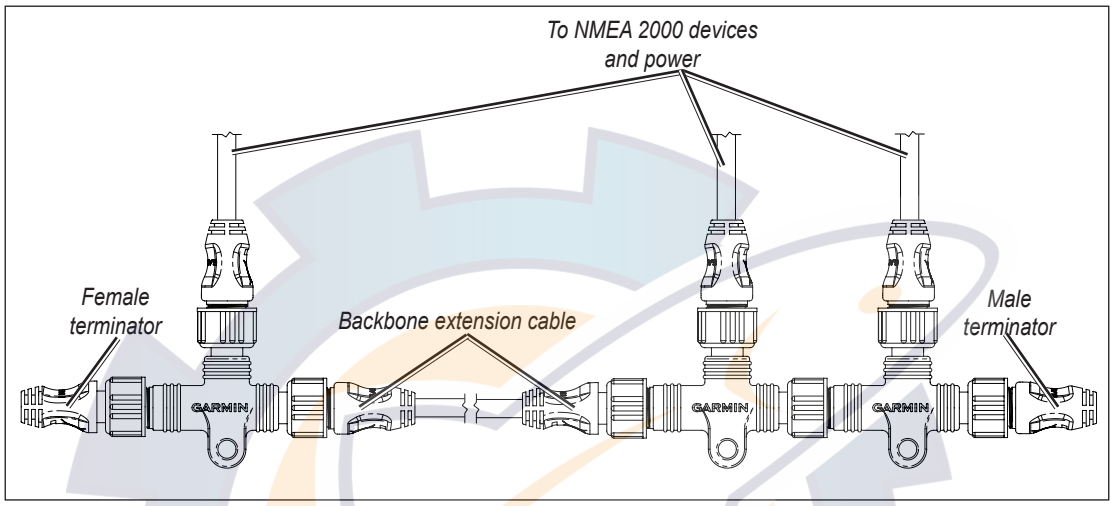
**NOTE:** The equation and examples provide conservative estimates for calculating voltage drop.

## Proper Termination

You must install terminators at the ends of your NMEA 2000 backbone for it to function correctly. You have two options when installing terminators on your NMEA 2000 network.

### 1. Typical Terminators

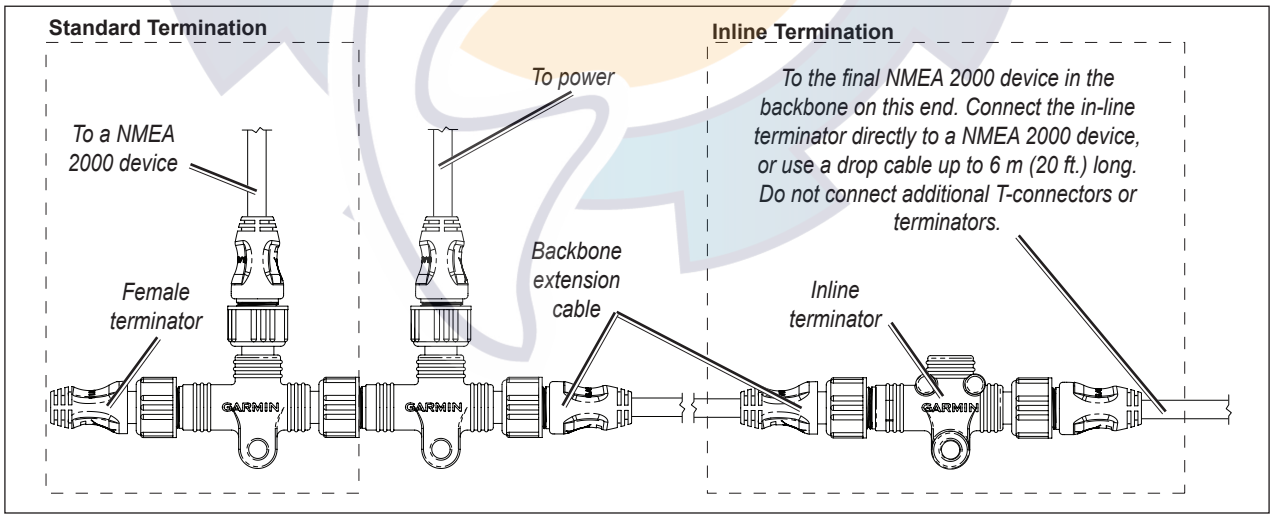
If your NMEA 2000 network is built with correct linear backbone construction, you will use one female terminator and one male terminator. The terminators are installed at opposite ends of your NMEA 2000 network.




**Using Standard Terminators**

### 2. In-line Terminators

If one or both of the NMEA 2000 devices at opposite ends of your NMEA 2000 network are separated from the rest of the NMEA 2000 network by a length of backbone cable, and the typical T-connector/drop cable/terminator combination is not feasible or is too bulky for the area, use an in-line terminator instead of the final T-connector on the backbone. Connect the final device to the in-line terminator with the appropriate length of drop cable, or connect the final device directly to the in-line terminator, without a drop cable.




**Using an Inline Terminator**

**CAUTION:** Do not use more than two terminators in a NMEA 2000 network.

**NOTE:** The in-line terminator connects to the NMEA 2000 backbone with a male connector, and to the final NMEA 2000 device with a female connector. Because of this, you can only use one in-line terminator on a NMEA 2000 network.

### Cable Length and Device Limits

When building your NMEA 2000 network, keep in mind these cable length limitations:

- The distance between any two points on the NEMA 2000 network must not exceed 100 m (328 ft). To estimate this distance, measure between the terminators on your backbone and add the length of the drop cable for the devices connected to the T-connnectors at the ends of the Network.
- The total length of all drop cables cannot exceed 78 m (256 ft).
- The maximum length of a single drop cable to a NMEA 2000 device is 6 m (20 ft).
- No more than 50 NMEA 2000 devices can be connected to your NMEA 2000 network.

## NMEA 2000 Glossary

**T-connector**—Three-way connector with 1 male and 2 female micro connectors. A T-connector is used to connect a NMEA 2000 device to the NMEA 2000 backbone.

**Terminator**—120 ohm resistor located at each end of the NMEA 2000 backbone. Proper termination helps ensure signal integrity across the entire length of the backbone.

**Inline Terminator**—Special terminator with male and female connectors on either end. Allows direct connection to the a device at the end of the NMEA 2000 backbone. Simplifies installation by not requiring a T-connector, Terminator, and Drop Cable for the device at the end of the backbone.

**Drop Cable**—Cable connecting a NMEA 2000 device to the NMEA 2000 backbone. Drop cables are limited to 6 m (20 ft) maximum length.

**Backbone Cable**—In conjunction with T-connectors, the backbone cables create the main communication path of the NMEA 2000 network. A backbone cable extends the NMEA 2000 backbone to connect NMEA 2000 devices located in different places on the boat. The maximum backbone cable length is 100 m (328 ft).

**Device**—Electronic hardware that connects to the NMEA 2000 network. A device may only receive data transmitted by other devices on the network, or may both transmit and receive data on the network.

**Network Power—**12 Vdc power supplied to the NMEA 2000 network. Power should be connected through a switch (instead of directly connected to the battery) because some devices are always on when NMEA 2000 power is present. Note: NMEA 2000 devices must operate from 9–16 Vdc, with a nominal voltage of 12 Vdc.

**LEN (Load Equivalency Number)**—This number indicates the amount of current a device draws from the NMEA 2000 network. 1 LEN = 50mA. Each device should have an LEN specified on the product or in the product documentation.

## Existing NMEA 2000 Installation Considerations

If your boat has an existing NMEA 2000 installation, and you would like to add Garmin NMEA 2000 equipment, there are a few things to consider:

**Cable Type:** Garmin uses NMEA 2000 micro connectors for all cables and connectors. Your existing NMEA 2000 network may use NMEA 2000 mini connectors and cables in the backbone. Mini connectors are larger than micro connectors, and you will need to use a converter or adapter to connect with Garmin NMEA 2000 devices.

**Power:** Is the existing NMEA 2000 network connected to power? A NMEA 2000 network must be connected to power to function correctly (page 5). **Do not connect the NMEA 2000 network to power in more than one location.**

**Termination:** Are terminators installed on the ends of the existing NMEA 2000 backbone? A NMEA 2000 network must be terminated to function correctly. Do not add more terminators to a NMEA 2000 network if it is already properly terminated.

**If you are unsure of any of these considerations, contact your boat manufacturer or a certified NMEA 2000 technician for assistance.**

# NMEA 2000 Checklist

Use this checklist to confirm your NMEA 2000 installation.

| | |
|---|---|
| | Is the NMEA 2000 network connected to power, and is the power balanced correctly on the network? (page 5) |
| | Is the NMEA 2000 network power connected through the ignition switch - if not, did you install a switch? (page 5) |
| | Is the NMEA 2000 power cable grounded? Is the drain wire (bare) connected to the same ground location? (page 5) |
| | Is the NMEA 2000 network backbone built using linear construction? (page 4) |
| | Are there terminators on both ends of the NMEA 2000 network? (page 7) |
| | Are all drop cables less than 20 ft (6 m)? (page 8) |

# NMEA 2000 PGN Information

All data transmitted on a NMEA 2000 network are organized into groups. These groups are identified by a parameter group number (PGN) that describes the type of data contained in the group. All Garmin NMEA 2000 devices use the proprietary PGN numbers 126720 and 61184. All the other PGN numbers follow the NMEA 2000 standard.

## PGN Information on Garmin NMEA 2000 Devices

The following tables list the PGN information for all Garmin NMEA 2000-compliant devices.

### GPSMAP 4000/5000 Series Chartplotters

| Receive | | Transmit | |
|---|---|---|---|
| 059392 | ISO Acknowledgment | 059392 | ISO Acknowledgment |
| 059904 | ISO Request | 059904 | ISO Request |
| 060928 | ISO Address Claim | 060928 | ISO Address Claim |
| 126208 | NMEA - Command/Request/Acknowledge Group Function | 126208 | NMEA - Command/Request/Acknowledge Group Function |
| 126464 | Transmit/Receive PGN List Group Function | 126464 | Transmit/Receive PGN List Group Function |
| 126992 | System Time | 126996 | Product Information |
| 126996 | Product Information | 127250 | Vessel Heading |
| 127250 | Vessel Heading | 127258 | Magnetic Variation |
| 127488 | Engine Parameters - Rapid Update | 128259 | Speed - Water Referenced |
| 127489 | Engine Parameters - Dynamic | 128267 | Water Depth |
| 127505 | Fluid Level | 129025 | Position - Rapid Update |
| 128259 | Speed - Water Referenced | 129026 | COG & SOG - Rapid Update |
| 128267 | Water Depth | 129029 | GNSS Position Data |
| 129025 | Position - Rapid Update | 129540 | GNSS Sats in View |
| 129026 | COG & SOG - Rapid Update | 129283 | Cross Track Error |

*(Continued)*

| | | | |
|---|---|---|---|
| 129029 | GNSS Position Data | 129284 | Navigation Data |
| 129539 | GNSS DOPs | 12985 | Navigation - Route/Waypoint Information |
| 129540 | GNSS Sats in View | 130306 | Wind Data |
| 130306 | Wind Data | 130312 | Temperature |
| 130310 | Environmental Parameters | | |
| 130311 | Environmental Parameters | | |
| 130312 | Temperature | | |
| 130313 | Humidity | | |
| 130314 | Actual Pressure | | |

## GMI 10

| **Receive** | | **Transmit** | |
|---|---|---|---|
| 059392 | ISO Acknowledgment | 059392 | ISO Acknowledgment |
| 059904 | ISO Request | 059904 | ISO Request |
| 060928 | ISO Address Claim | 060928 | ISO Address Claim |
| 126208 | NMEA - Command/Request/Acknowledge Group Function | 126208 | NMEA - Command/Request/Acknowledge Group Function |
| 126464 | Transmit/Receive PGN List Group Function | 126464 | Transmit/Receive PGN List Group Function |
| 126992 | System Time | 126996 | Product Information |
| 126996 | Product Information | | |
| 127250 | Vessel Heading | | |
| 127488 | Engine Parameters - Rapid Update | | |
| 127489 | Engine Parameters - Dynamic | | |
| 127505 | Fluid Level | | |
| 128259 | Speed - Water Referenced | | |
| 128267 | Water Depth | | |
| 129025 | Position - Rapid Update | | |
| 129026 | COG & SOG - Rapid Update | | |
| 129029 | GNSS Position Data | | |
| 129044 | Datum | | |
| 129283 | Cross Track Error | | |
| 129284 | Navigation Data | | |
| 129285 | Navigation - Route/WP information | | |
| 129539 | GNSS DOPs | | |
| 129540 | GNSS Sats in View | | |
| 130306 | Wind Data | | |
| 130310 | Environmental Parameters | | |
| 130311 | Environmental Parameters | | |
| 130312 | Temperature | | |
| 130313 | Humidity | | |
| 130314 | Actual Pressure | | |

## GPS 17x

| Transmit | | Receive | |
|---|---|---|---|
| 059392 | ISO Acknowledgment | 059392 | ISO Acknowledgment |
| 060928 | ISO Address Claim | 059904 | ISO Request |
| 126208 | NMEA - Command/Request/Acknowledge Group Function | 060928 | ISO Address Claim |
| 126464 | Transmit/Receive PGN List Group Function | 126208 | NMEA - Command/Request/Acknowledge Group Function |
| 126992 | System Time and Date | | |
| 126996 | Product Information | | |
| 129025 | Position - Rapid Update | | |
| 129026 | COG & SOG - Rapid Update | | |
| 129029 | GNSS Position Data | | |
| 129539 | GNSS DOPs | | |
| 129540 | GNSS Sats in View | | |

## GFS 10

| Transmit | | Receive | |
|---|---|---|---|
| 059392 | ISO Acknowledgement | 059392 | ISO Acknowledgement |
| 060928 | ISO Address Claim | 059904 | ISO Request |
| 126208 | NMEA–Command/Request/Acknowledge Group Function | 060928 | ISO Address Claim |
| 126464 | Transmit/Receive PGN List Group Function | 126208 | NMEA–Command/Request/Acknowledge Group Function |
| 126996 | Product Information | 127489 | Engine Parameters - Dynamic |
| 127489 | Engine Parameters–Dynamic | 127497 | Trip Parameters, Engine |
| 127497 | Trip Parameters, Engine | 127505 | Fluid Level (when calibrated on a Garmin chartplotter or instrument) |
| 127505 | Fluid Level (when calibrated on a Garmin chartplotter or instrument) | | |

## Intelliducers

| Transmit | | Receive | |
|---|---|---|---|
| 059392 | ISO Acknowledgement | 059392 | ISO Acknowledgement |
| 060928 | ISO Address Claim | 059904 | ISO Request |
| 126208 | NMEA–Command/Request/Acknowledge Group Function | 060928 | ISO Address Claim |
| 126464 | Transmit/Receive PGN List Group Function | 126208 | NMEA–Command/Request/Acknowledge Group Function |
| 126996 | Product Information | | |
| 128267 | Water Depth | | |
| 130312 | Temperature | | |

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Part Number 190-00891-00 Rev. A