



# CAN NETWORKS USING HORNER PRODUCTS

## Products Specifications and Installation Data

For detailed installation, configuration and other information, refer to the hardware manual of the controller you are using. See **Additional References** (page 16).

### 1 BEFORE Setting Up a CAN Network...

Note: CsCAN and DeviceNet both utilize a Controller Area Network (**CAN**).

- Determine the basic overall tasks involved in setting up a CAN network. A checklist is provided in this document for your convenience.
- Understand the CAN cable system and how to set up a network *efficiently*. Important points to know include grounding, power, termination, wire type / length, and network layout.

### 2 Basic Tasks Involved in Setting UP a CAN Network

**Use the following checklist as a handy tool to set up a CAN Network.** It provides important points about the design and construction of the CAN Network:

#### A. Layout The Network On Paper Before Setting Up

- Determine power supply placement and size. More detail is explained in the next task, *Wiring*.
- Determine where the nodes are to reside and the distances involved including the overall length of the network, the length of trunk lines, and the length of the drops.
- Assign node addresses that are on the network.
- Determine termination on the two far ends of the network (requires resistors). More detail is explained in the **CAN Wiring Rules** (page 6). Also, refer to the hardware manual of the controller you are using to determine if additional CAN requirements apply. (See the **Additional References** section in this document for the manual numbers.)

#### B. Wiring

- **Wire/cable:** Use the proper Belden wire type or equivalent for the network as specified in the **CAN Wiring Rules** (page 6).
- **Shielding:** Assure shields are connected at one end of a segment – they are not continuous. Shielding on SmartStix, LX and ColorTouch controllers – The FG pin on the CAN connector can not be connected to ground pin on the power supply. Put the cable shield directly to earth ground.
- **Network length:** Do not exceed the maximum length determined by the baud rate and cable type. See **Table 3** (page 6).
- **Drop length:** Total drop length for each drop should not exceed 6m (20 feet). A drop may include more than one node. The drop length adds to the overall network length.
- **Termination:** 121 ohm, 1%, 1/4watt or greater wattage is recommended. 120 ohm, 5%, 1/4 Watt or greater wattage may be used in most cases. Two termination resistors total should be used between CN\_H and CN\_L, one at each physical end of the network.

- **Proper cable pairs together:** Data wires as a pair (white/blue). Power wires as a pair (red/black).
- **Power Supplies:** 23VDC to 25VDC recommended. This is a tighter tolerance than the input power of the OCS controllers. The voltage for the CAN should not exceed 25VDC where many OCS controllers allow power up to 30VDC. If the CAN power exceeds 25VDC, it can cause damage to the CAN transceivers.
- **Grounding power supplies:** In applications requiring multiple power supplies, make sure the V- of all supplies is connected together and to earth ground at one place only.
- **V- isolation:** Make sure V- is isolated from earth ground at each power supply except for one.
- **Multi-meter Network Test:** It is possible to use a multi-meter to test the network for problems once it is wired, terminated and powered but before any nodes are connected. It is important that no nodes are connected if conducting this test or results may not be meaningful.
  - Check for 24VDC between V+ and V- at each end of the network and at several, if not all, of the node connections. Absence of voltage indicates a wiring problem.
  - Check for approximately 60 Ohms of resistance between CN\_H and CN\_L at each end of the network and at several, if not all, of the node connections. A measurement of 121 (or 120) Ohms or of infinite resistance or of any other resistance indicates a wiring problem.

### C. Nodes

**Note:** When setting up nodes, be aware that some units are set via software.

- **Network Baud Rate:** Assure the baud rate and cable length match the cable type used.
- **Node ID:** Make sure there are no duplicate Node ID numbers.
- **Equipment grounding:** Each OCS unit must be grounded properly;
  - Remove the paint from the cabinet door behind the OCS mounting nuts. Use star washers to dig into the door to insure a good ground.
  - Connect a ground strap from the door to the Earth ground in the cabinet. Cabinet door hinges do not assure a solid ground connection from the door to the cabinet.

## 3 Understanding CAN Networks

### 3.1 Using CsCAN

CsCAN is a peer-to-peer network developed in 1993 by Horner Electric. The CsCAN Network is based on CAN, which has many desirable features such as ruggedness and ease of configuration.

It is important to understand how to set up a network *efficiently* and to know the CAN cable system including grounding, power, wire type / length, termination, and network layout.

### a. Power and Grounding

The CAN and at least the network transceivers in each node need to be powered by the CAN power supply. Equipment at each node will normally require additional power. It is highly recommended that a power supply be dedicated solely to the CAN. Using the same power supply to power controllers, I/O and other things can induce noise onto the CAN.

1. A power supply of 24VDC ( $\pm 4\%$ ) (23VDC to 25VDC) at 16A maximum is required for use in a CAN. **Note:** This is a tighter specification than needed for most OCS units. A range of 15VDC to 25VDC is the maximum acceptable at any given node.
2. As a general rule of thumb, each node on a network consumes 75mA of power at 24VDC, equivalent to 1.8W at 24VDC.
3. With thick cable, a single network segment can have a maximum of 8A. To use a 16A power supply, the power supply must be located in the center of two network segments.
4. Thin cable has a maximum of 3A.
5. For ideal operation, locate the power supply in the center of the network to minimize voltage drops.
6. If local codes require the local CAN power supply to be earth grounded, connect the V- power conductor to a good earth ground **at one place only** on the network preferably at a physical endpoint.
7. It is very important to also ground each node using the grounding studs or earth ground on all devices power connections. **Note: This is a separate connection from the shield connection on the CAN.**

Multiple power supplies can be used. This may be required if excessive network lengths or high numbers of nodes cause the network power to drop below the recommended or acceptable ranges. In this case, only one power supply must have V- connected to earth ground. The remaining power supplies need to be isolated. Do not connect the V+ connection between power supplies.

**NOTE:** However the CAN is wired, the V- connection (along with CN\_H and CN\_L) absolutely **MUST** be connected between every node. 2-wire CAN wiring (CN\_H and CN\_L only) without a continuous V- connection can not be expected to function.

### b. Shielding

Correct shielding of the CAN is important for proper communications. Incorrect shielding can cause ground loops through the shield and actually induce noise onto the communication lines rather than shield them from it. Refer to CAN drawings Figures 4 and 5 (page 8) and notice how the shields are connected at only one end of any network segment.

1. The shield from any given length of CAN wiring should be connected to earth ground at one point only.
2. Shields from several sections can be connected together to make larger sections, but they still must only be grounded at one point only.
3. Shields are not necessarily connected to every node. SmartStix, LX, and ColorTouch controllers do not have an internal connection from shield to earth ground, even though the shield pin is still there. If needed, the shield is connected straight to an earth ground in this case.
4. CN\_H and CN\_L are a twisted pair and are shielded separately from V+ and V- which are also a twisted pair and are shielded. Both of these shielded, twisted pairs shall then be contained together within an additional shielded casing. This is already taken care of when using the recommended Belden cable. See Table 2 (page 5) for more details.
5. Do not use junction boxes for shield connections unless they are earth grounded, in which case only ONE of them is used to connect the shield for any given section of CAN wiring.

Table 1 – Summary of Horner Products CAN Power and Grounding		
Product	CAN Volts	Shield Grounding
OCS1xx, OCS2xx,	18-25	Ground one end segment (pin 3) or Hard earth ground.
Graphic OCS250,	18-25	Ground one end segment (pin 3) or Hard earth ground.
RCS210/250,	18-25	Ground one end segment (pin 3) or Hard earth ground.
Mini OCS	18-25	Ground one end segment (pin 3) or Hard earth ground.
SX	18-25	Ground one end segment (pin 3) or Hard earth ground.
LX	None – Internally Powered	Shield to earth ground on one side.
NX	None – Internally Powered	Ground one end segment (pin 3) or Hard earth ground.
Color Touch OCS300	Revision A-J: 25V / Revision K or Higher: Internally Powered	Ground one end segment (pin 3) or Hard earth ground.
Color Touch OCS451, OCS551, OCS651	None – Internally Powered	Shield to earth ground on one side. Choke at one end. See Examples of CAN wiring drawings in the Color OCS Hardware Manual. (Refer to the <b>Additional References</b> section in this document for the manual numbers.)
Digital Stix	18-25V	Shield to earth ground on one side.
Analog Stix	17.5-25V	Install choke in every Analog SmartStix device (part # HE200CRF005).
QX	None – Internally Powered	Ground one end segment (pin 3) or Hard earth ground.

### c. CAN Cable

The 5-wire, multi-conductor copper cable used in a CAN includes:

1. Two wires used as a transmission line for network communications.
2. Two wires used to transmit network power.
3. One conductor used as an EMI shield.

Cabling is available in a variety of current-carrying capacities. On a CAN, every device must, at least, power its network transceivers from the network power supply. Some devices draw all of their power from the network supply. For a CAN, thick and thin cable is used as indicated:

1. **Thick cable:** Use for long distances and more power. Usually used for Trunk cable.
2. **Thin cable:** Use for shorter distances. Usually used for drop cables or where cable flexibility is needed.

<b>Table 2 - CsCAN / DeviceNet Cable Specifications</b>	
<b>Thick Cable –</b> general specifications (e.g., Belden 3082A)	Two twisted shielded pairs –Common axis with drain wire in center. One signal pair (#18), blue/white; One power pair (#15) black/red. Separate aluminized mylar shields around power pair and signal pair. Overall foil/braid shield with drain wire (#18), bare*. High Speed (Vp=75% min), low loss, low distortion, data pair (to keep propagation delays to a minimum). 8 amp maximum current capacity in power pair. PVC insulation on power pair. Industrial temperature range. Nominal OD 0.48". Bend radius (fixed) 7 x diameter (3.3")
<b>Thin Cable –</b> general specifications (e.g., Belden 3084A)	Two twisted shielded pairs –Common axis with drain wire in center. One signal pair (#24), blue/white; One power pair (#22) black/red. Separate aluminized mylar shields around power pair and signal pair. Overall foil/braid shield with drain wire (#22), bare*. High Speed (Vp=75% min), low loss, low distortion, data pair (to keep propagation delays to a minimum). 3 amp maximum current capacity in power pair. PVC insulation on power pair. Industrial temperature range. Nominal OD 0.28". Bend radius (fixed) 7 x diameter (1.9")
Terminating Resistor	121 Ohms, 1%, ¼ Watt or larger wattage
Redundancy	Not Supported
Network Power for Node devices	Nominal 24 VDC ±4% (23 VDC to 25 VDC)
Allowed Nodes (Bridging excluded)	64 nodes
Allowed Nodes (with Bridging)	253 nodes
Data Packet Size	0-8 bytes with allowance for message fragmentation
Duplicate Address Detection	Addresses verified at power-up
Error Detection / Correction	CRC – retransmission of message if validity not acknowledged by recipient.
* The drain wire connects shields within the cable and serves as a means to terminate the shield into the connector.	

The above Thick and Thin cables are generic types that have been tested and are known to work satisfactorily in a CAN. Other cables are available in a variety of different offerings such as FLEX, HAZ-Duty, Class I (600V), UV Resistant, etc. that may better meet the environmental requirements of your application. These, plus a multitude of pre-made cables that comply with the above specification are available and may work but have not been tested and verified.

#### d. Bus Length

Several factors affect the maximum length of the bus including the accumulated length of drop lines, cable type, and the network data rate. Each drop line is limited to one network, but it can have multiple nodes. A drop line can not exceed 6 meters (20 ft.).

When measuring cable length, normally it is taken as the distance between the terminating resistors on each end of the trunk line and does not include the length of any drop lines. (Do not exceed cumulative drop line length.) However, if the cable length from one terminating resistor to the node at the end of the last drop line is greater, then take that length as the overall cable length.

Networks exceeding the maximum total cable length or consisting of more than 64 nodes must make use of repeaters. Up to 3 repeaters (HE200CGM100) can be used for a single network to extend the length or for a total of up to 253 nodes. A repeater must be used for every 64 nodes or every maximum length of wiring. For example, a 125KBaud network running on Thick Cable can be extended from 500m to 1000m using 1 repeater, to 1500m using 2 repeaters and to 2000m using 3 repeaters.

Table 3 provides specifications related to the wire type / length.

Table 3 - CAN Baudrate vs. Total Cable Length			
Network Data Rate	Maximum Distance* (Thick Cable)	Recommended Distance** (Thick Cable)	Maximum Distance (Thin Cable)
125Kbit / sec.	500m (1,640 feet)	1200 feet?	100m (328 feet)
250Kbit / sec.	200m (656 feet)	600 feet?	100m (328 feet)
500Kbit / sec.	100m (328 feet)	240 feet?	100m (328 feet)
1Mbit / sec.	40m (131 feet)	No	x
* The maximum distance (thick wire) specifications are taken from the CAN Specification.			
** The recommended distance (thick wire) specifications are based on Horner's real-world application experience.			
Cumulative Drop Line Length			
Network Data Rate	Cumulative Drop Line Length		
500Kbit / sec.	39m (128 feet)		
250Kbit / sec.	78m (256 feet)		
125Kbit / sec.	156m (512 feet)		
Maximum cable length for any one drop is 6m (20 feet).			

#### e. CAN Wiring Rules

1. Wire the CAN in a daisy-chained or trunk / drop line fashion.
2. The two nodes at the physical end-points need to have **121 ohm, 1%, ¼ Watt terminating resistors** connected across the CN\_L and CN\_H terminals. It is possible to get away with 120 ohm, 5%, ¼ Watt resistors in many cases. No more or less than two terminating resistors should be used. Terminating resistors should NOT be used anywhere else on the network.
3. Use data conductors (CN\_L and CN\_H) that are 24 AWG shielded twisted pair for "thin cable" and 18 AWG shielded twisted pair for "thick cable." They must also have 120-ohm characteristic impedance. In typical industrial environments, use a Belden wire #3084A ("thin"). Use #3082A("thick") for network cable lengths greater than 100 meters. Place data conductors (CN\_L and CN\_H) into a twisted, shielded pair together (Blue/White pair).
4. Use power conductors (V- and V+) that are 22 AWG twisted-pair for "thin cable" and 15 AWG twisted-pair for "thick cable." Place power conductors (V- and V+) into a twisted, shielded pair together (Black/Red pair).
5. If local codes require the local CAN power supply to be earth grounded, connect the V- power conductor to a good earth ground **at one place only** on the network, preferably at a physical endpoint. If multiple power supplies are used, only one power supply may have V- connected to earth ground. The remaining power supplies need to be isolated from earth ground but all the V- conductors should be connected together. The V+ conductors should be separate, one per power supply.
6. For a segment of cable between two nodes, the cable shield should be connected to ground **at one end of the cable segment only**.
7. A CAN (without repeaters) is limited to 64 nodes (with 63 cable segments) with a maximum combined cable length of 500m (1640 feet) at 125KBaud using Thick cable.
8. Up to four CAN segments, which adhere to the above rules, may be connected together using three CAN repeaters (HE200CGM100). In this manner, a CAN may be extended to 253 nodes with a total cable distance of 2000m (6560feet) at 125KBaud and Thick cable.

## f. Network Connector

Table 4– CAN Port Pins			
Pin	Signal	Wire Color	Description
1	V-	Black	Power -
2	CN_L	Blue	Signal -
3	SHLD	Bare	Shield *
4	CN_H	White	Signal +
5	V+	Red	Power +

\* Not all products use pin 3 such as: LX, NX, Color Touch OCS451, OCS551, OCS651, and QX.

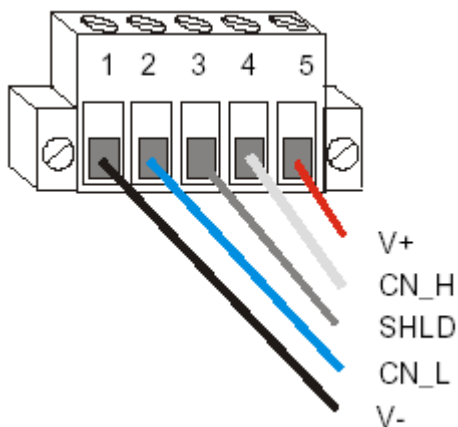


Figure 1 – Network Connector

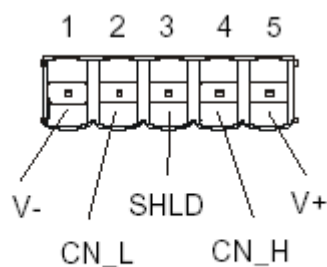


Figure 2 – As viewed at the OCS



Figure 3 – Adapter Connector

The adapter connector shown in Figure 3 is available (HE200ACC512). It allows an m12 cable, which is readily available from many sources, to be used with any of the OCS products. The use of the adapter connector and m12 cables can greatly reduce network installation time and significantly increase reliability.

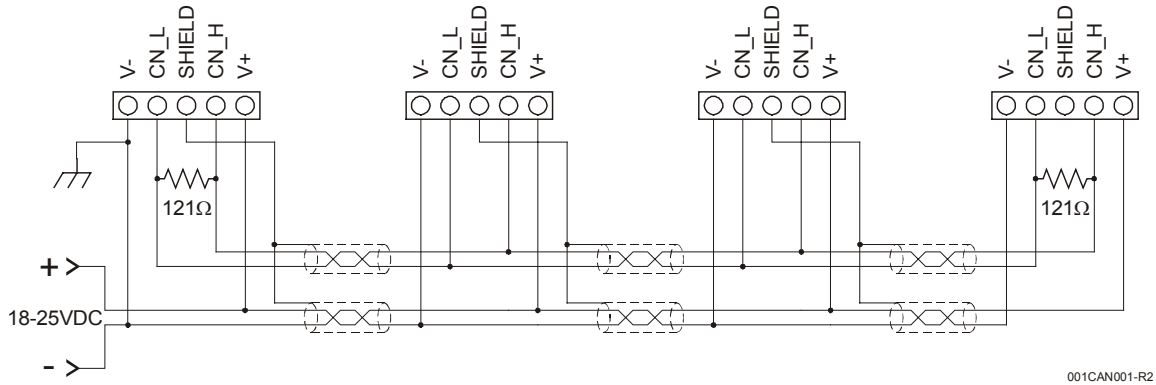
## g. Wiring

When wiring the network, make sure all conductors are continuous from one end to the other with the exception of the shield and the V+ conductor. The shield is grounded at one end only per cable segment. The V+ conductor is continuous to all nodes that require it unless multiple power supplies are used to power the network.

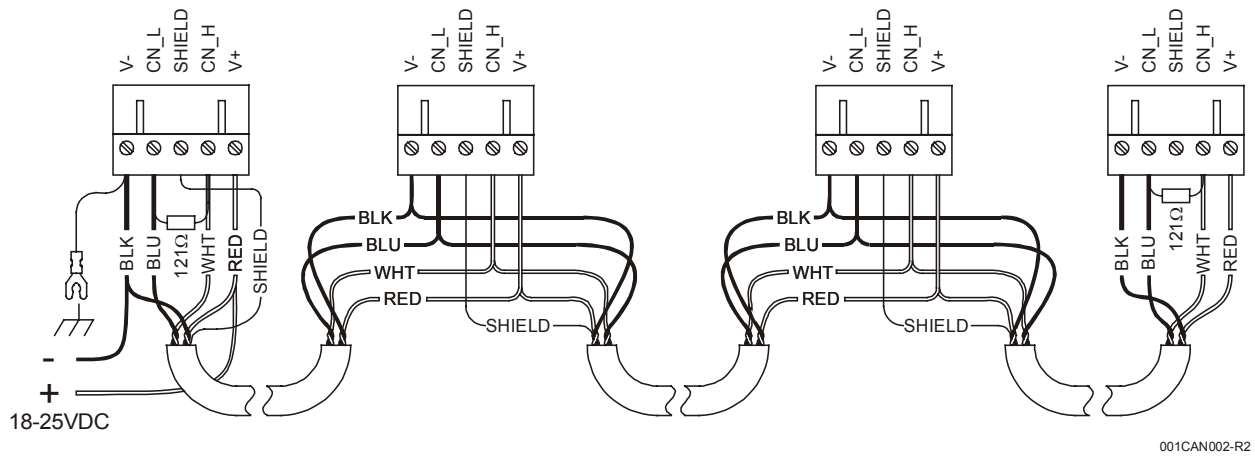
When connecting nodes to the network, assure the node can be removed without disturbing communications on the system. This is accomplished if the node has a removable terminal strip or connector. However if the node has a fixed terminal strip, a drop line should be used.

**Examples for OCS Products Except the LX-OCS and the Color OCS451, OCS551, and OCS651**

**Note:** Figures 4 and 5 are similar to one another, but Figure 5 also shows the colors of the wire.



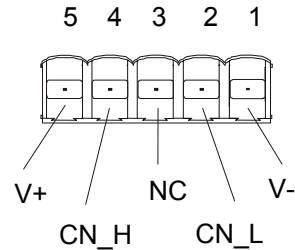
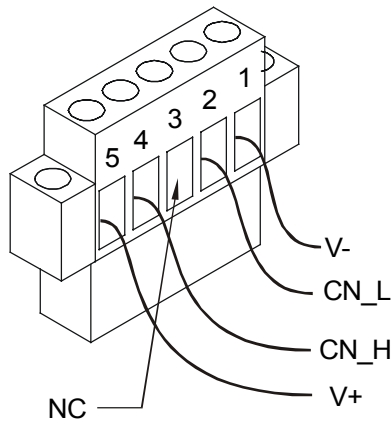
**Figure 4 – CAN Schematic Drawing**



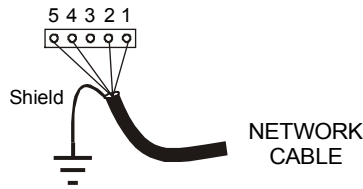
**Figure 5 – CAN Wiring Drawing**

**Note:** To optimize CAN reliability in electrically noisy environments, the CAN power supply needs to be isolated (dedicated) from the primary (node) power.

**Example of LX-OCS**



**\* Note:**  
 Ensure that the Shield wire of Network cable is connected to earth ground. It is not connected to the connector.



**Figure 6 - Network Connector**

**Figure 7 (CAN port) – As Viewed looking at the LX**

**Note:** To optimize CAN network reliability in electrically noisy environments, the CAN power supply needs to be isolated (dedicated) from the primary power. **The CAN Shield must be attached to the panel as close to the OCS/LX as possible.**

**Examples of CAN Wiring Drawings for Color OCS451, OCS551, and OCS651**

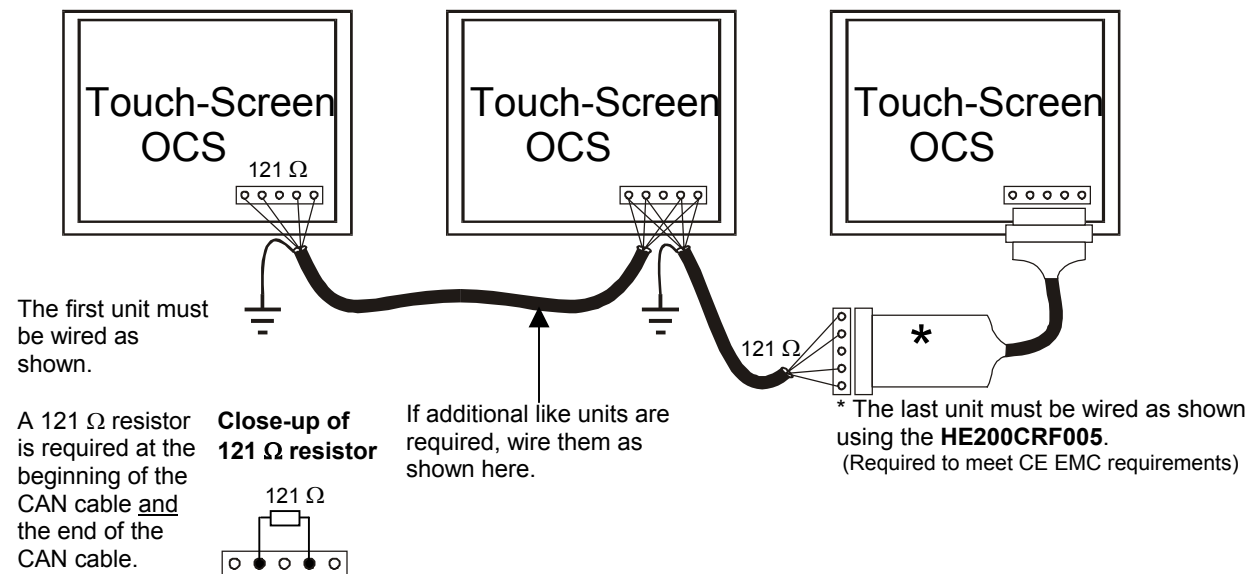
Drawings are provided in this section to depict typical CAN configurations using various models of Touch Screen OCS controllers and other devices. Examples of controllers and devices used in the examples include the following devices:

Controller	Examples
Touch-Screen OCS	<ul style="list-style-type: none"> <li>Color Touch OCS (OCS451, OCS551, OCS651)</li> <li>LX (LX280, LX300)</li> </ul>
Text OCS	<ul style="list-style-type: none"> <li>OCS1xx, OCS2xx</li> </ul>
Graphic OCS	<ul style="list-style-type: none"> <li>OCS250</li> </ul>
RCS	<ul style="list-style-type: none"> <li>RCS116, RCS2xx</li> </ul>
SmartStix	<ul style="list-style-type: none"> <li>Analog I/O modules</li> <li>Digital I/O modules</li> </ul>
RF and Surge Suppression (Required to meet CE EMC requirements)	<ul style="list-style-type: none"> <li>HE200CRF005</li> </ul>

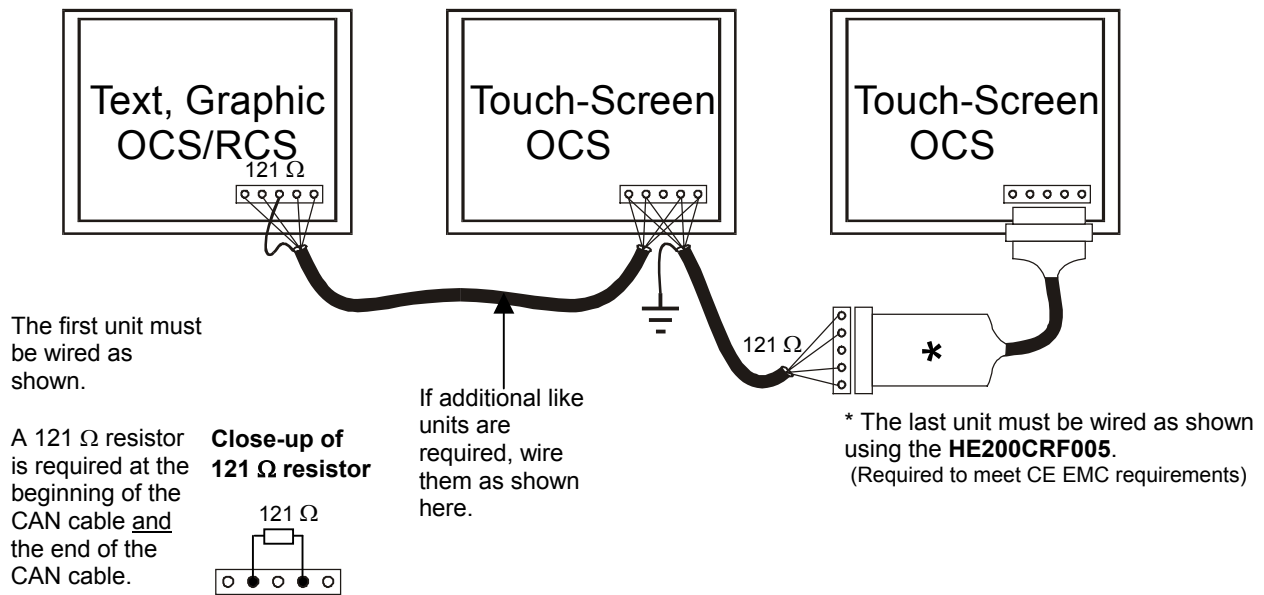
**Note:**

**If configuring only two units:** Ignore the center device(s) in the following drawings by covering them with a piece of paper. Wire the two remaining units accordingly.

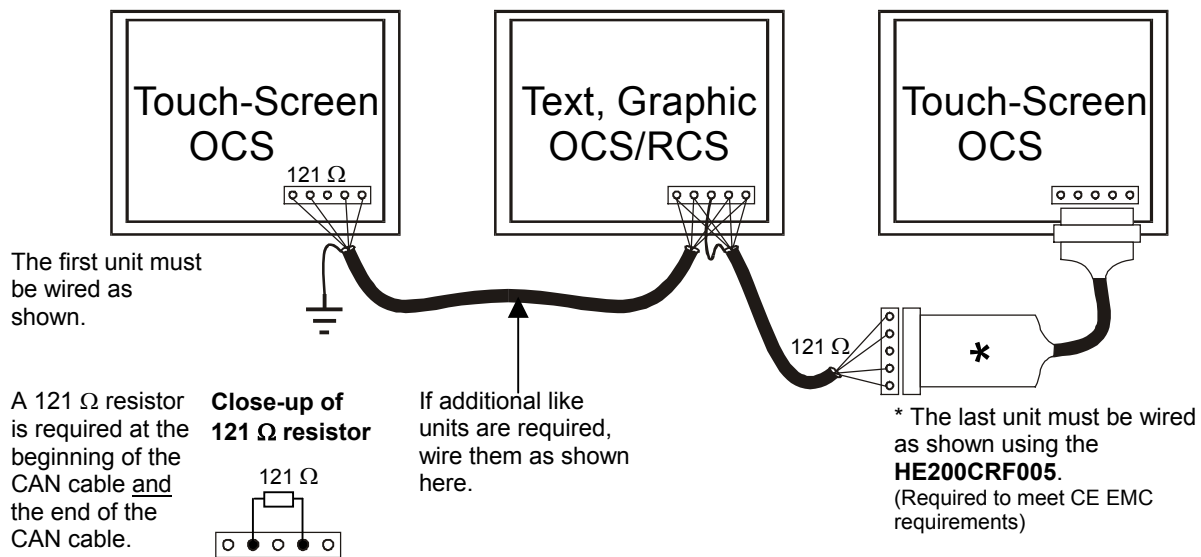
**If configuring more than three units:** Instructions are provided in drawings to wire multiple units.



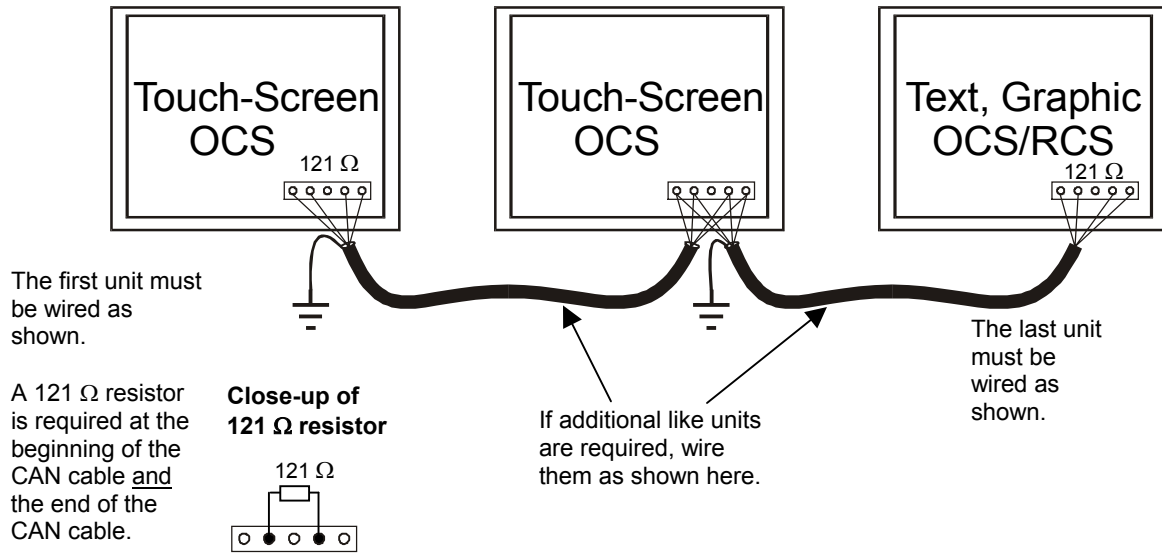
**Figure 8 –CAN Wiring Between Touch Screen OCS Units**



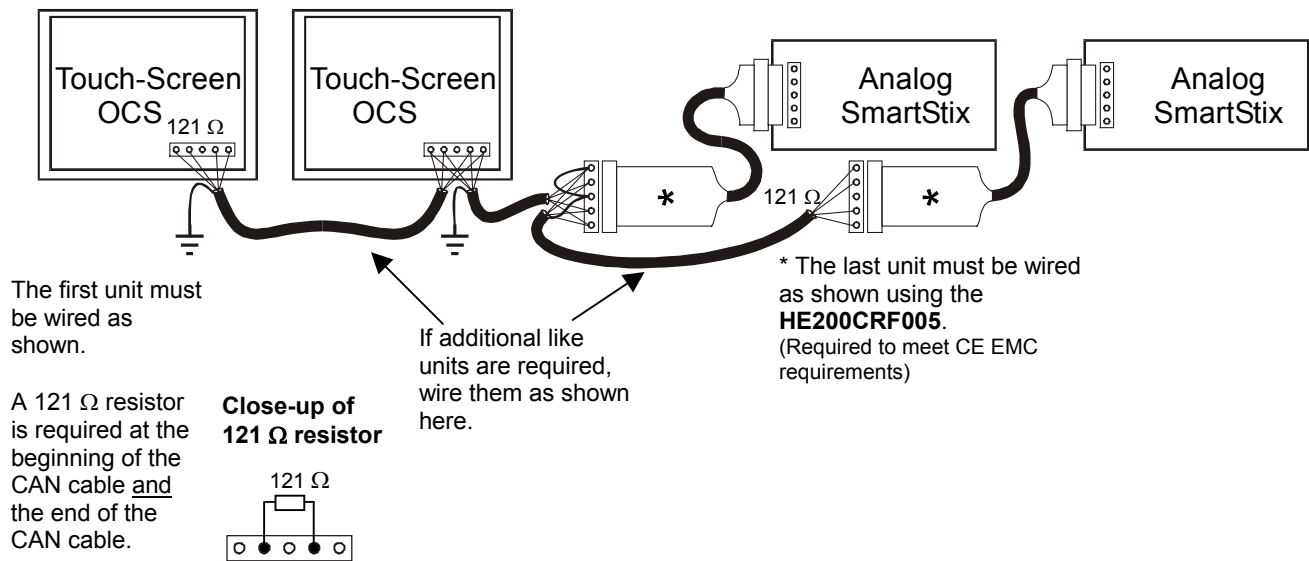
**Figure 9 – CAN Wiring Between Text OCS/GraphicOCS/RCS and Touch Screen OCS Units**



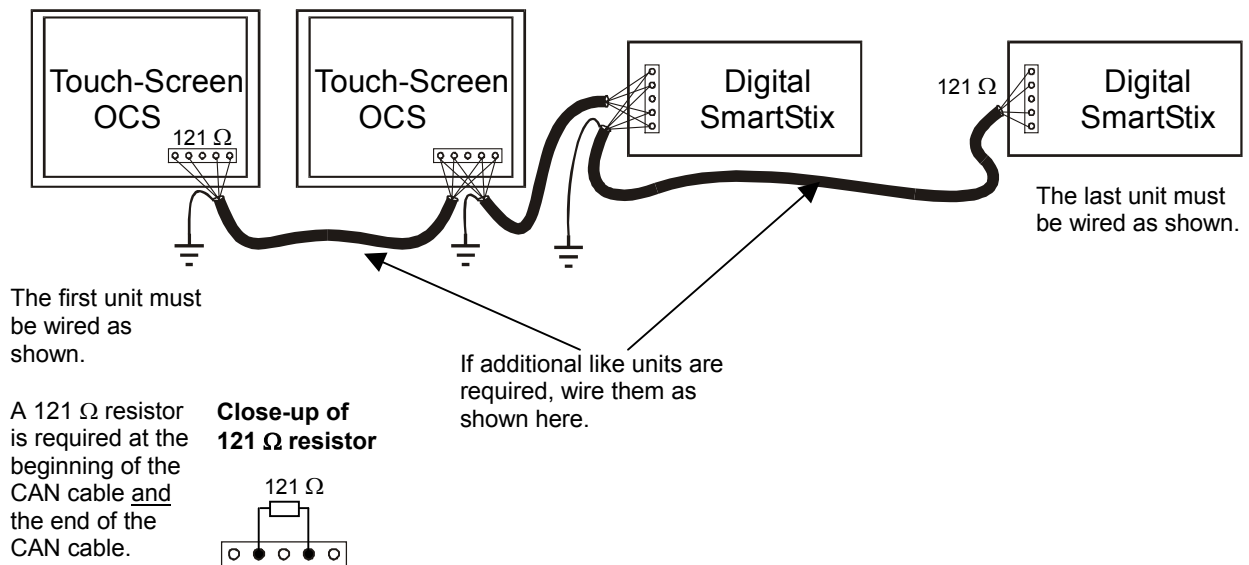
**Figure 10 - CAN Wiring Between Touch Screen OCS and Text OCS/GraphicOCS/RCS Units**



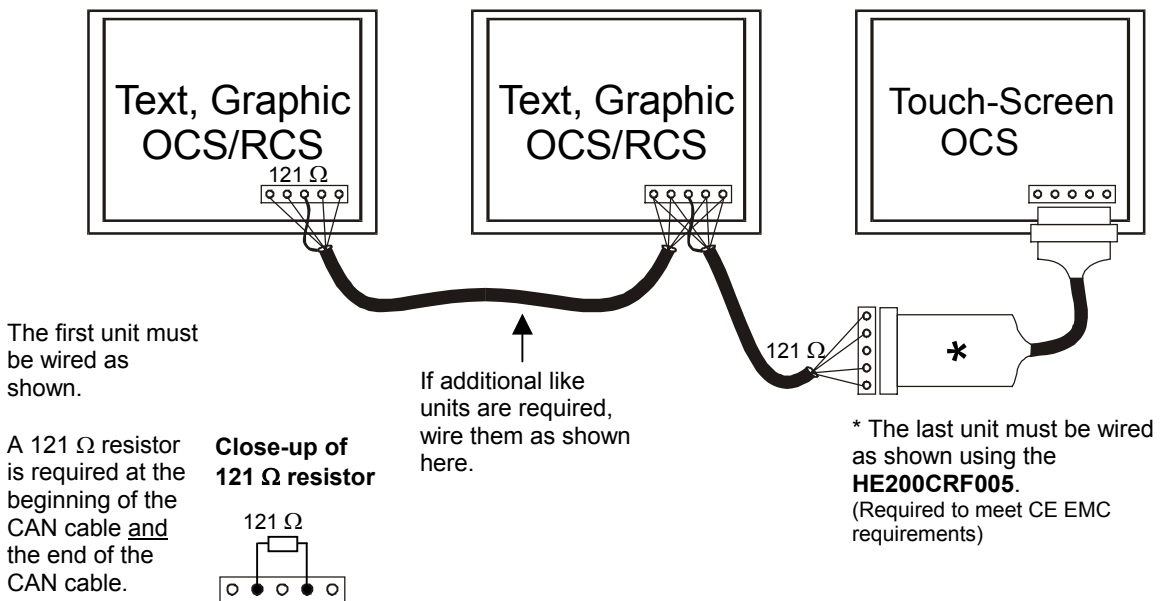
**Figure 11 - CAN Wiring Between Touch Screen OCS and Text OCS/ GraphicOCS/ RCS Units**



**Figure 12 - CAN Wiring between Touch Screen OCS and Analog SmartStix Modules**

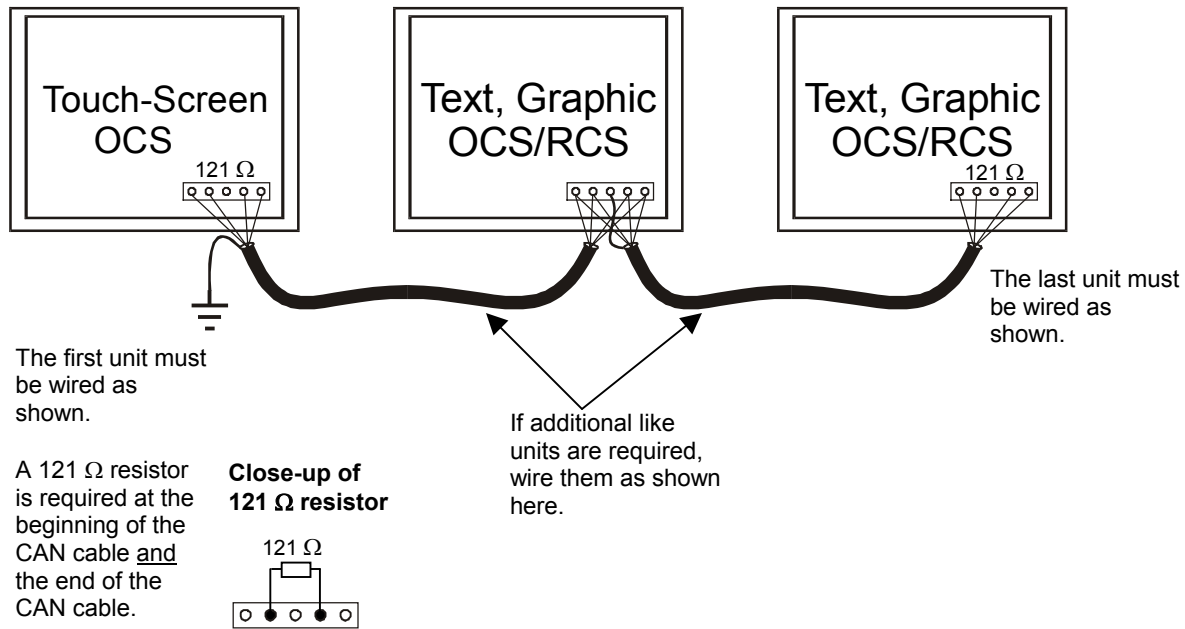


**Figure 13 - CAN Wiring between Touch Screen OCS and Digital SmartStix Modules**



**Figure 14 - CAN Wiring between Text, GraphicOCS, RCS and Touch Screen OCS**

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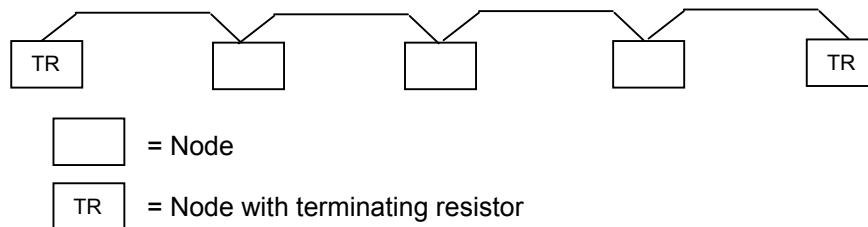


**Figure 15 - CAN Wiring between Text, GraphicOCS, RCS and Touch Screen OCS**

**h. Network Layout**

CsCAN and DeviceNet both utilize a Controller Area Network, or CAN. The CAN must be wired either in a daisy-chained fashion such that there are exactly two physical endpoints, Figure 16, or using limited branching in a trunk/drop line topology, Figure 17. Each of the two physical ends of the network must be terminated regardless of overall length. A 3-foot network between 2 nodes may still fail if not terminated properly.

The network must never be wired in a “ring” fashion where there is no physical end to the network. The network must never be wired in a “star” fashion where there is a central connection point with branches out to each node. The sole exception to the “star” method is if each branch is no more than 6 meters (20 feet) in length. When implementing this method, terminating resistors should be placed at the ends of the two longest branches. Regardless, this is not a recommended method of wiring a CAN.



**Figure 16 – Daisy-chained Topology**

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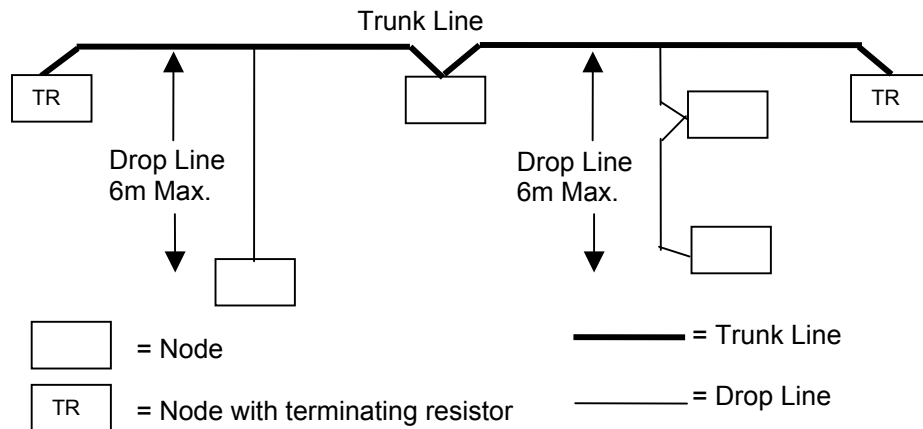


Figure 17 – Trunk/Drop Line Topology

## 4 SAFETY

When found on the product, the following symbols specify:



**Warning:** Consult user documentation.



**Warning:** Electrical Shock Hazard.

**WARNING:** To avoid the risk of electric shock or burns, always connect the safety (or earth) ground before making any other connections.

**WARNING:** To reduce the risk of fire, electrical shock, or physical injury it is strongly recommended to fuse the voltage measurement inputs. Be sure to locate fuses as close to the source as possible.

**WARNING:** Replace fuse with the same type and rating to provide protection against risk of fire and shock hazards.

**WARNING:** In the event of repeated failure, do not replace the fuse again as a repeated failure indicates a defective condition that will not clear by replacing the fuse.

**WARNING:** Only qualified electrical personnel familiar with the construction and operation of this equipment and the hazards involved should install, adjust, operate, or service this equipment. Read and understand this manual and other applicable manuals in their entirety before proceeding. Failure to observe this precaution could result in severe bodily injury or loss of life.

For detailed installation and a handy checklist that covers panel box layout requirements and minimum clearances, refer to the hardware manual of the controller you are using. (See the **Additional References** section in this document.)

- All applicable codes and standards need to be followed in the installation of this product.
- For I/O wiring (discrete), use the following wire type or equivalent: Belden 9918, 18 AWG or larger.

Adhere to the following safety precautions whenever any type of connection is made to the module.

- Connect the green safety (earth) ground first before making any other connections.
- When connecting to electric circuits or pulse-initiating equipment, open their related breakers. Do not make connections to live power lines.
- Make connections to the module first; then connect to the circuit to be monitored.
- Route power wires in a safe manner in accordance with good practice and local codes.
- Wear proper personal protective equipment including safety glasses and insulated gloves when making connections to power circuits.
- Ensure hands, shoes, and floor are dry before making any connection to a power line.
- Make sure the unit is turned OFF before making connection to terminals. Make sure all circuits are de-energized before making connections.
- Before each use, inspect all cables for breaks or cracks in the insulation. Replace immediately if defective.

## 5 ADDITIONAL REFERENCES

The following table indicates the hardware manual numbers for the controller you are using. Hardware manuals contain detailed installation, configuration and other pertinent information. See the **Technical Support** section in this document for the web site address to download references and obtain revised editions.

Additional References	
Controller	Manual Number
<b>QX Series Hardware</b> e.g. HE-QX4510, HE-QX551, HE-QX651, HE-QX500	MAN0797
<b>NX Series Hardware</b> e.g. HE-NX220, HE-NX221, HE-NX250, HE-NX251	MAN0781
<b>Operator Control Station Hardware (OCS, OCX)</b> e.g., OCS1XX / 2XX; Graphic QCS250	MAN0227
<b>Remote Control Station Hardware (RCS [except RCS116], RCX)</b> e.g., RCS210, RCS250	
<b>Color Touch QX Hardware</b> e.g., OCS300, OCS 301, OCS 350, OCS 351 e.g., OCS 451, OCS 551, OCS 651	MAN0465
<b>QX LX Series Hardware</b> e.g., LX280 / LX300; RCS116	MAN0755
<b>MiniQX / MiniRCS / MiniOCX / MiniRCX Hardware</b> e.g., HE500QXxxx	MAN0305
Other Useful References	
CAN Networks	MAN0799
Cscape Programming and Reference	MAN0313
DeviceNet™ Implementation	SUP0326
Wiring Accessories and Spare Parts Manual	MAN0347

## 6 TECHNICAL SUPPORT

For assistance and manual updates, contact Technical Support at the following locations:

**North America:**

(317) 916-4274

[www.heapg.com](http://www.heapg.com)

email: [techspt@heapg.com](mailto:techspt@heapg.com)

**Europe:**

(+) 353-21-4321-266

[www.horner-apg.com](http://www.horner-apg.com)

email: [techsupport@hornerirl.ie](mailto:techsupport@hornerirl.ie)

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