

# ARC156 Wiring

## Technical Instructions

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# Contents

<b>What is ARC156?</b> .....	<b>1</b>
ARC156 vs. ARCNET .....	1
<b>ARC156 network configurations and requirements</b> .....	<b>1</b>
ARC156 network configurations .....	1
ARC156 network requirements .....	2
ARC156 network segment requirements .....	3
<b>Communications wiring</b> .....	<b>4</b>
Avoiding noise.....	4
ARC156 wiring specifications .....	4
To wire the communication cable .....	5
<b>Adding multiple ARC156 networks to a router</b> .....	<b>7</b>
<b>Token passing</b> .....	<b>8</b>
<b>To upgrade a legacy controller network to ARC156</b> .....	<b>8</b>
<b>Troubleshooting an ARC156 network</b> .....	<b>9</b>
ARC156 reconfigurations .....	9
Locating the problem.....	9
Using an oscilloscope to troubleshoot the network .....	11

## What is ARC156?

For communications on an ExecB or Exec 6 controller network, ALC uses ARC156 which is a unique implementation of the industry standard ARCNET (Attached Resource Computer Network) protocol.

### ARC156 vs. ARCNET

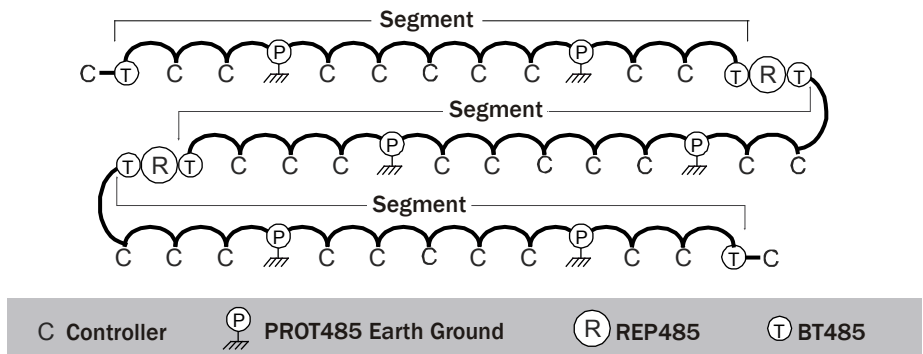
	<b>ARC156</b>	<b>ARCNET</b>
Speed	156K bits/second	2.5M bits/second
Coupling	Opto coupled, d.c.	Transformer coupled
Mode	Backplane	Dipulse Hybrid
Connector type	3 pos screw terminal	BNC
Wire type	twisted pair	RG-59/U coax
Topology	daisy chain	star, with active hub
Termination	BT485 or 120 Ohm	75 Ohm

## ARC156 network configurations and requirements

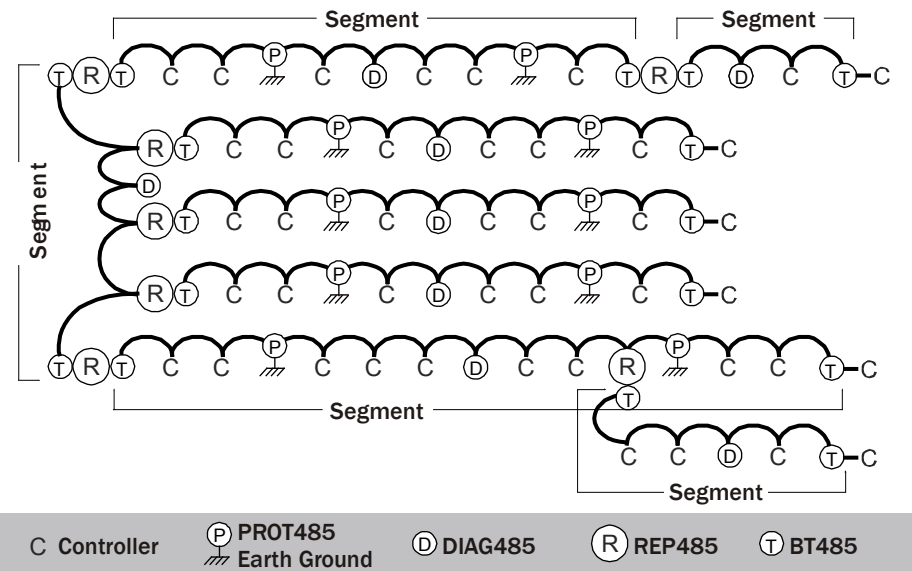
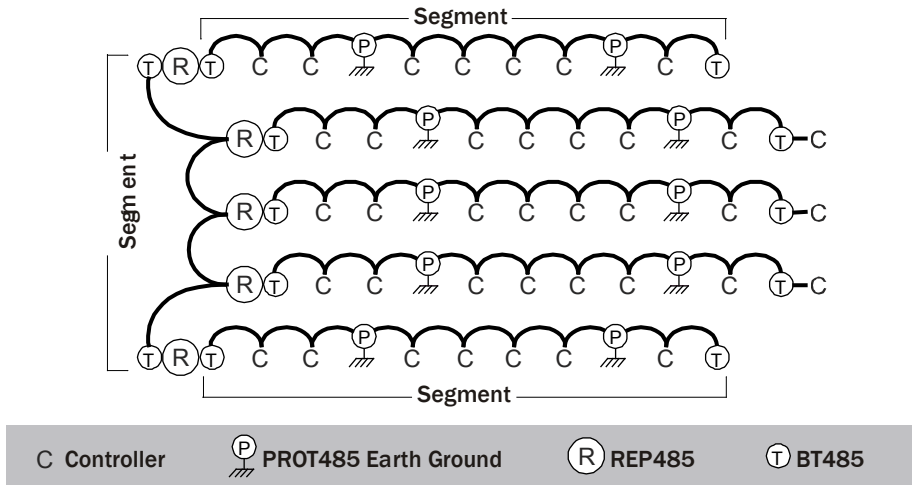
### ARC156 network configurations

An ARC156 network can be in a daisy-chain or hybrid configuration if repeaters are used as described in *ARC156 network requirements* (page 2). Each network segment must be in a daisy-chain configuration. See *Network segment requirements* (page 3).

#### Sample daisy-chain configuration:



**Sample hybrid configurations:**



**ARC156 network requirements**

An entire ARC156 network must have:

- Exec 6 or later firmware and driver for each controller
- No more than 99 controllers, excluding repeaters

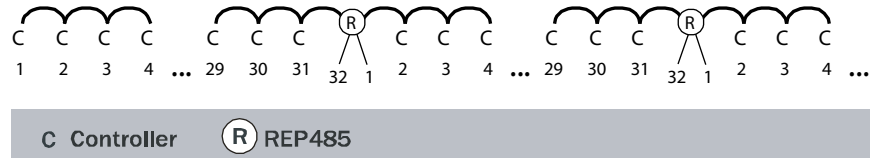
**NOTE** If your system requires more than 99 controllers on the ARC156 network, see *Adding multiple ARC156 networks to a router* (page 7).

- A unique MAC address for each controller on the network

- A REP485 repeater after every 31 devices or after 2000 feet (whichever is reached first), and at each branch of a hybrid network.

#### NOTES

- Each repeater begins a new network segment. See *Network segment requirements* (page 3). A repeater counts as the last device in one segment and the first device in the next segment.



- A communication packet from one controller to another cannot pass through more than 4 repeaters.
- See the *REP485 Technical Instructions* (<http://accounts.automatedlogic.com>).
- A PROT485 for surge protection at each place wire enters or exits the building and within 250 feet (76 meters) of every controller. For maximum protection, place a PROT485 within 6 feet (1.8 meters) of each controller. See the *PROT485 Technical Instructions* (<http://accounts.automatedlogic.com>).

#### ARC156 network segment requirements

An ARC156 network can consist of multiple network segments. See the samples in *ARC156 network configurations* (page 1). Each segment of an ARC156 network must:

- Be wired in a daisy-chain configuration.
- Be no longer than 2000 feet (610 meters).
- Have 32 or fewer devices (controllers and repeaters).
- Have one of the following:
  - A BT485 at each end (unless the segment is less than 10 feet [3 meters] long) to add bias and prevent signal distortions due to echoing. See the *BT485 Technical Instructions* (<http://accounts.automatedlogic.com>)
  - A 1/2 watt, 120 Ohm terminator at each end to prevent signal distortions due to echoing and one DIAG485 near the center of the network segment to add bias. You must put the DIAG485's **Bias** jumper in place. See the *DIAG485 Technical Instructions* (<http://accounts.automatedlogic.com>).

#### NOTES

- Whether using BT485's or terminators/DIAG485, you can add one or more DIAG485's to a network segment for diagnostic purposes. You must remove the **Bias** jumper on the diagnostic DIAG485's.
- To attach a 120 Ohm terminator, turn off the controller's power, then attach the terminator to the **Net +** and **Net -** terminals.

## Communications wiring

ExecB and Exec 6 controllers can communicate on a high-speed 156 kbps controller network.

### Avoiding noise

Avoid running communication wires or sensor input wires next to AC power wires or the controller's relay output wires. These can be sources of noise that can affect signal quality.

Common sources of noise are:

Spark igniters	Induction heaters
Radio transmitters	Large contactors (i.e., motor starters)
Variable speed drives	Video display devices
Electric motors (> 1hp)	Lamp dimmers
Generators	Fluorescent lights
Relays	Parallel runs with power lines
Transformers	Other electronic modules

If noise is a problem and you cannot move the wiring, use ferrite clamp-on chokes on the cabling to improve signal quality.

### ARC156 wiring specifications

Below are the specifications for ARC156 wiring. The wire jacket and UL temperature rating specifications list two acceptable alternatives. Halar has a higher temperature rating and a tougher outer jacket than SmokeGard, and it is appropriate for use in applications where you are concerned about abrasion. Halar is also less likely to crack in extremely low temperatures.

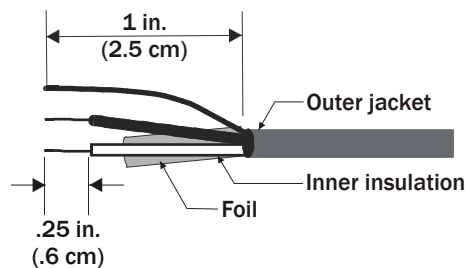
**NOTE** Use the specified type of wire and cable for maximum signal integrity.

Description	Single twisted pair, low capacitance (12pF), CL2P, 22 AWG (7x30), TC foam FEP, plenum rated cable
Conductor	22 AWG (7x30) stranded copper (tin plated) 0.030 in. (0.762 mm) O.D. <b>NOTE</b> 24 AWG can be used for segments <200 ft. (6.7 m).
Insulation	Foamed FEP 0.015 in. (0.381 mm) wall 0.060 in. (1.524 mm) O.D.
Color code	Black/white
Twist lay	2 in. (50.8 mm) lay on pair 6 twists/foot (20 twists/meter) nominal
Shielding	Aluminum/Mylar shield with 24 AWG (7x32) TC drain wire

Jacket	<b>SmokeGard</b> (SmokeGard PVC) 0.021 in. (0.5334 mm) wall 0.175 in. (4.445 mm) O.D.  <b>Halar</b> (E-CTFE) 0.010 in. (0.254 mm) wall 0.144 in. (3.6576 mm) O.D.
DC resistance	15.2 Ohms/1000 feet (50 Ohms/km) nominal
Capacitance	12.5 pF/ft (41 pF/meter) nominal conductor to conductor
Characteristic impedance	100 Ohms nominal
Weight	12 lb/1000 feet (17.9 kg/km)
UL temperature rating	<b>SmokeGard</b> 167 °F (75 °C)  <b>Halar</b> -40 to 302 °F (-40 to 150 °C)
Voltage	300 Vac, power limited
Listing	UL: NEC CL2P, or better

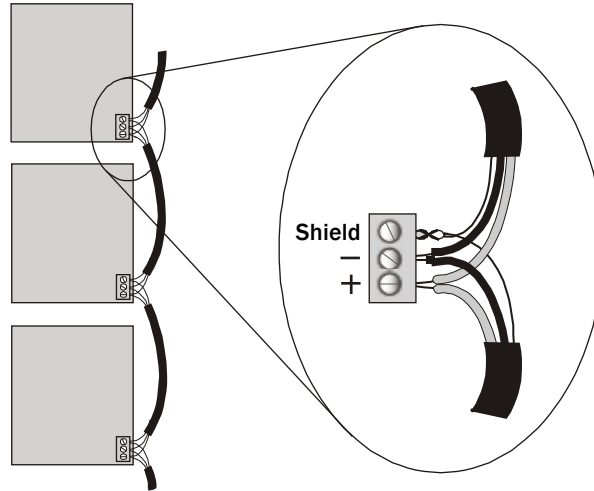
### To wire the communication cable

- 1 Partially cut, then bend and pull off 1" of the outer jacket of the cable(s). Do not nick the inner insulation.



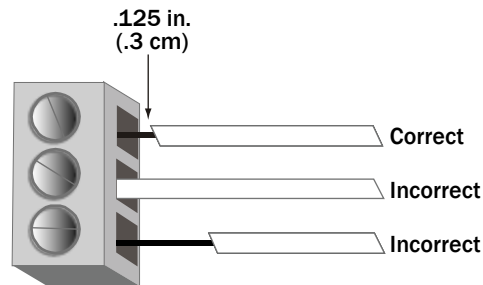
- 2 Strip about .25 inch (.6 cm) of the inner insulation from each wire.
- 3 If wiring two cables to the controller, twist together the shield wires from both cables.

- 4 Insert the wires into the terminal block.



#### CAUTIONS

- Do not allow more than .125 inch (.3 cm) bare communication wire to protrude.



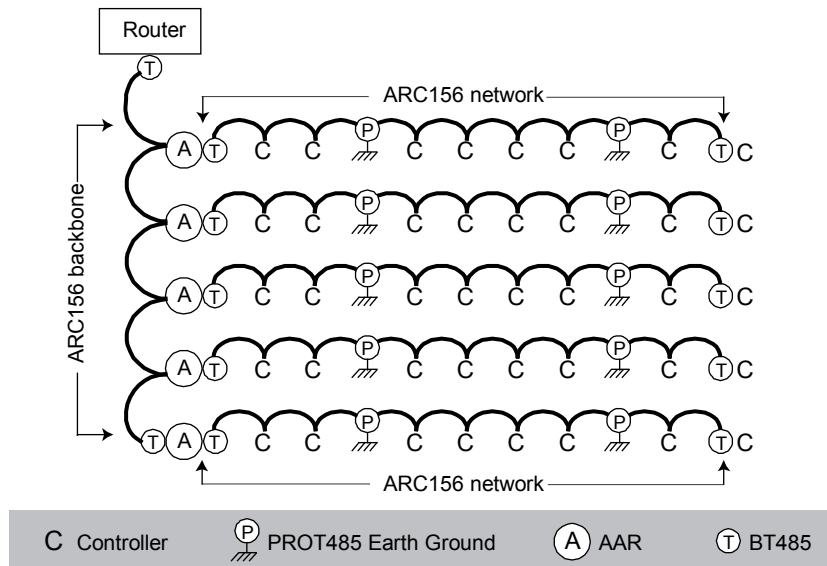
- If bare communication wire contacts the cable's foil shield, shield wire, or a metal surface other than the terminal block, communications may fail.

**NOTE** Do not ground the shield to earth ground or to the controller's power ground. The PROT485 and the individual controllers allow the shield to float a limited amount so that there are no ground loops. If the voltage on the shield becomes too great relative to the earth ground, then the excess voltage is bled off with protective devices on the PROT485 or on the controllers.



## Adding multiple ARC156 networks to a router

If your system requires more than 99 controllers on an ARC156 network, you can use AAR controllers to add multiple ARC156 networks to a router. The AAR is a BACnet router that provides communication between two ARC156 networks. For more information, see the *AAR Technical Instructions* (<http://accounts.automatedlogic.com>).



### NOTES

- The AAR can be located anywhere on its ARC156 network; it does not have to be at one end of the network.
- Do not place another AAR on an AAR's ARC156 network. Cascading AAR's greatly reduces performance of the network.
- The ARC156 backbone is an ARC156 network and must follow the above rules for ARC156 networks.

### TIPS

- Put controllers on the AARs' networks where possible instead of on the ARC156 backbone to improve network performance.
- If possible, put all controllers for related terminal units and their air source below one AAR to localize network traffic between them. If this is not possible, try to put the air source controller on the backbone.
- Although an ARC156 network can contain up to 99 controllers, use  $\pm 50$  controllers as a starting number for the network. Numerous factors such as network configuration and performance affect the number of controllers that an AAR's network can have.

## Token passing

On an ARC156 network, each controller's ARCNET coprocessor controls the token passing scheme. The token passes rapidly from controller to controller without intervention. Because the token passes only to controllers that exist on the network, controllers do not need to be sequentially addressed.

If a controller does not respond to its token, the controller drops from the loop and does not receive its token again until the network is reconfigured. A network reconfiguration allows controllers that were not participating in the token passing to enter their address into the token passing loop. This process takes about 3 seconds. If a controller has just been powered up or has not received the token for about 13 seconds, the controller initiates a network reconfiguration.

Each controller can send only one data packet each time it gets the token, then the controller passes the token. No controller can keep the token. The longest time a controller typically waits for its token is 0.5 seconds.

Workstations can communicate with the ARC156 network without stopping the token. The controllers can continue to communicate global points, colors, alarms, and heat/cool requests even while a workstation transfers memory to a controller.

## To upgrade a legacy controller network to ARC156

### PREREQUISITES

- Verify that wiring is adequate. See *ARC156 wiring specifications* (page 4).
- Verify the network configuration is acceptable. See *ARC156 network configurations* (page 1).
- Verify that all controllers can use Exec 6.0 or later. To determine this, see each controller's *Technical Instructions* (<http://accounts.automatedlogic.com>) or the *Technical Handbook*.

To upgrade:

- 1 With the controller network running at 38.4 kbps or 9600 bps, download an Exec 6.0 (or higher) driver into every controller. Do this over a direct connection through a router, or set the controller to 38.4 kbps or 9600 bps and connect to the controller's local access port using an APT in 485 mode.
- 2 Add a 120 Ohm terminator to each end of the network segment.
- 3 Add at least one DIAG485 to the middle of the network segment. Set the **Bias** jumper to add bias.  
  
You can have more than one DIAG485 per network segment, but only one DIAG485 should have the **Bias** jumper set to add bias.
- 4 On each controller, set the baud rate jumper for 156 kbps communication. The controllers will not be able to communicate on the controller network until all controllers are set to 156 kbps and a network reconfiguration starts the ARC156 network.

- 5 To reconfigure the controller network immediately, remove and then restore power to one of the controllers. Otherwise, wait up to 30 minutes for the controllers to reconfigure themselves.

**NOTE** A controller network divided into segments may experience several reconfigurations until all the segments are synchronized.

- 6 Add other devices (like a REP485 or PROT485) to the network as necessary to improve the signal quality.

## Troubleshooting an ARC156 network

If WebCTRL cannot communicate with one or more controllers on an ARC156 network or if the network continually reconfigures, you have a network problem and must determine if the problem is caused by:

- The network wiring
- The network configuration
- A particular controller
- The network's environment

### ARC156 reconfigurations

An ARC156 network normally reconfigures itself when a controller is added to or taken off the network. For example, turning a controller's power off or on. If communication with controllers is intermittent or downloads are excessively slow, see if the network is continually reconfiguring. To do this, check any controller's:

- Transmit and Receive LED's. These turn off for 1 second each time the network reconfigures.
- Modstat to see if an unexpected number appears in the **Total** field shown below.

```
ARC156 reconfigurations during the last hour (cleared upon
reset) :
      Total . . . . . 15
```

### Locating the problem

#### NOTES

- If the network was working correctly and then began to have problems, consider any recent changes to the network as a possible source of the problem.
- If the network that is reconfiguring is downstream from an AAR and it contains a repeater, the AAR may be causing the reconfigurations. See [http://info.automatedlogic.com/library/books/Bugs\\_network/23091.htm](http://info.automatedlogic.com/library/books/Bugs_network/23091.htm) for more information.

Follow the steps below until you locate the problem.

- 1 Verify that the ARC156 network uses the recommended cable. See *ARC156 wiring specifications* (page 4).
- 2 Check drawings of the completed network to verify that it meets the *ARC156 network requirements* (page 2) and the *Network segment requirements* (page 3).
- 3 Try to obtain a modstat for each controller.
  - o If the **Initiated by this node** field shows a number, check the network wiring connection for that controller, the controller with the next lower MAC address, and all controllers located between these two controllers.

```
ARC156 reconfigurations during the last hour (cleared
upon reset):
    Total . . . . . 15
    Initiated by this node. . . . . 15
```

- o If you cannot obtain a modstat for a controller, check the controller's LED's to see if it is running correctly. (See the controller's *Technical Instructions* for a description of its LED's.)

If the controller's LED's do not indicate a problem with the controller, check the controller's network wiring connection.

**To check a controller's network wiring connection, verify that:**

- a) The shield wire is connected properly. The shield must not touch the metal housing or tie to earth ground.
- b) The cable's outer jacket is not stripped more than one inch. If so, the wires may have become untwisted, causing noise.
- c) The wires are connected correctly to the terminal blocks.  
Black wire to **Net -**  
White wire to **Net +**  
Shield wire to **Shield**
- d) No external source is causing noise or interference. See *Avoiding noise* (page 4).

- 4 Isolate the problem network segment.
  - a) If the network has a repeater, disconnect it, then check the Transmit and Receive LED's or a modstat of a controller on each network segment to determine which segment is reconfiguring. If the network has multiple repeaters, perform this step for one repeater at a time.
  - b) Divide the questionable segment in half, placing a BT485 or a 120 Ohm terminator at both ends of each segment. If using a 120 Ohm terminator, add a DIAG485 to the new segments.
  - c) Determine which of the new segments has the problem, then repeat step a. on that segment.
  - d) Continue splitting each problem segment in half until you identify the cause.

## Using an oscilloscope to troubleshoot the network

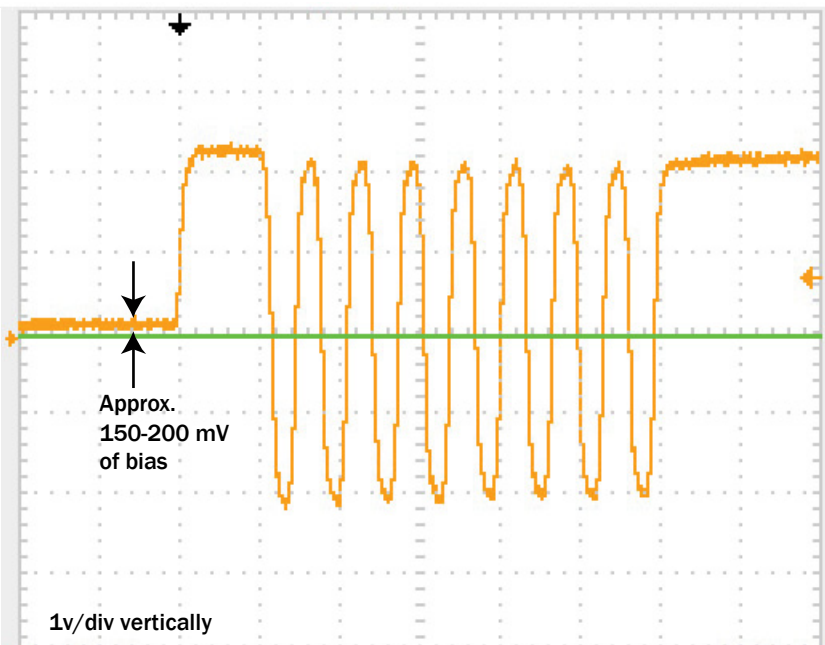
To help diagnose problems with the ARC156 network, use an oscilloscope that has the following features:

- 1MHz or greater bandwidth
- 5 megasamples per second sampling rate
- Battery power (not 120VAC)

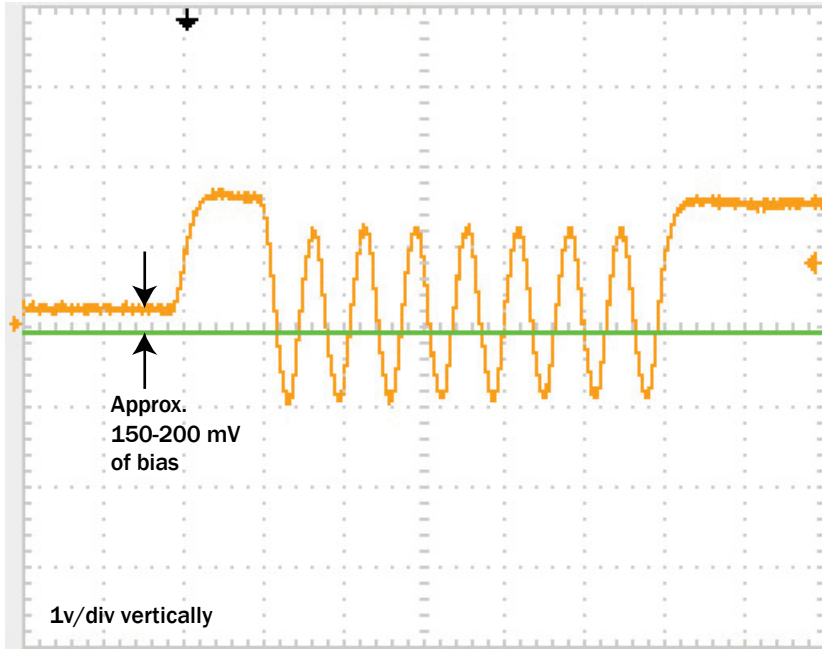
When capturing waveforms, use the following guidelines:

Property	Recommended setting
Differential mode connections	The scope probe's ground is connected to the Net- connector and the probe's tip is connected to the Net+ connector
Vertical scaling	1–2 Volts/division
Horizontal scaling	>1 $\mu\text{s}/\text{division}$ to view transition to idle 1–5 $\mu\text{s}/\text{division}$ to view shape of waveform 20–50 $\mu\text{s}/\text{division}$ to view bias level and larger portion of signal
Coupling mode	DC
Trigger level	0.5–1V (can be adjusted based on amplitude)
Trigger slope	Positive or rising edge to view transition from idle Negative or falling edge to view transition to idle.

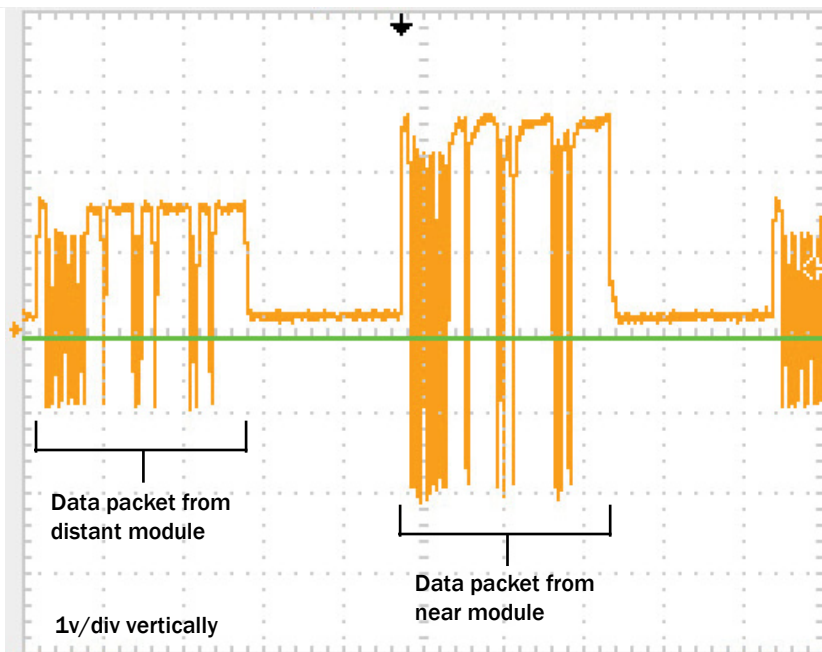
When troubleshooting, view a waveform capture from a trouble-free network segment, then compare it with the normal examples below. Look at several frames of the problem segment. Use the figures and descriptions below to discover a possible cause.

Waveform	Notes
<p><b>Normal character waveform with short cable and 2 BT485's</b></p>  <p>The waveform shows a sharp transition from a low bias level to a high level, followed by a series of pulses. A green horizontal line indicates the bias level. Annotations include 'Approx. 150-200 mV of bias' and '1v/div vertically'.</p>	<ul style="list-style-type: none"> <li>• A normal waveform has sharp vertical transitions at change of bit levels.</li> <li>• The corners of the waveforms have near-90° transitions.</li> <li>• For differential connections, the signal is symmetrical above and below the 0-volt line.</li> <li>• For differential connections, the signal swings from 1–2 volts. If signal swings are &lt;0.75 volt, check for too many terminators on the segment. If the signal swings are &gt;2.5 volts, the segment may not have 2 terminators.</li> </ul>

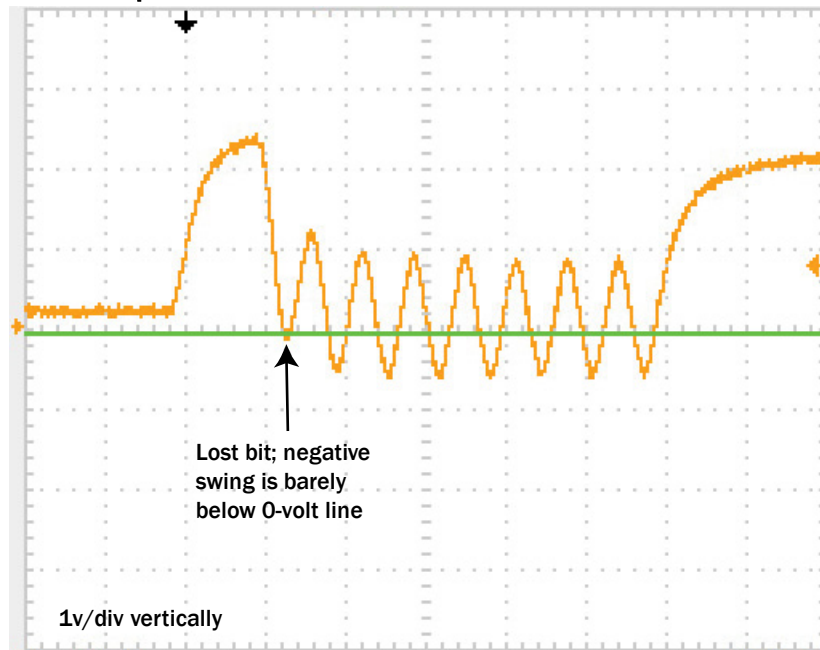
Normal character waveform  
with long cable and 2 BT485's



Normal packet waveform  
with long cable and 2 BT485's

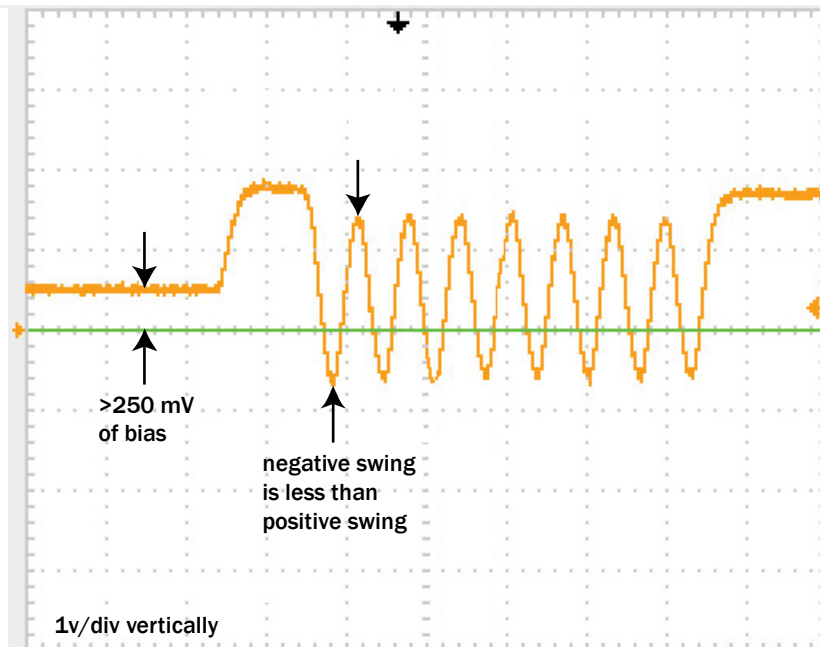


## Excessive capacitance



- The waveform has slow, curving transitions at the change of bit levels. This indicates that the cable may be too long or may not be the recommended type, or a non-ALC protection device may be on the segment.
- Each negative transition should go at least 0.5 volt below the 0-volt line. With too much capacitance, this will not happen with all negative transitions.
- For differential connections, the waveform is not symmetrical above and below the 0-volt line.

## Excessive bias current



- For differential connections, bias level is incorrectly greater than 0.250 volt.
- Can be caused by a segment having more than 1 DIAG485 with its bias jumper in place, excessive line resistance, bad wiring junctions, or defective controllers.