MS/TP Wiring

Technical Instructions

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Contents

What is MS/TP?

An ExecB controller network can use the BACnet MS/TP (Master-Slave/Token-Passing) protocol for communications. This document contains ALC's recommendations for configuring and wiring an MS/TP network that will provide the best network performance with ALC controllers. However, ALC controllers will work on any BACnet-compliant MS/TP network.

An MS/TP network can communicate at 9600 bps, 19.2 kbps, 38.4 kbps, or 76.8 kbps.
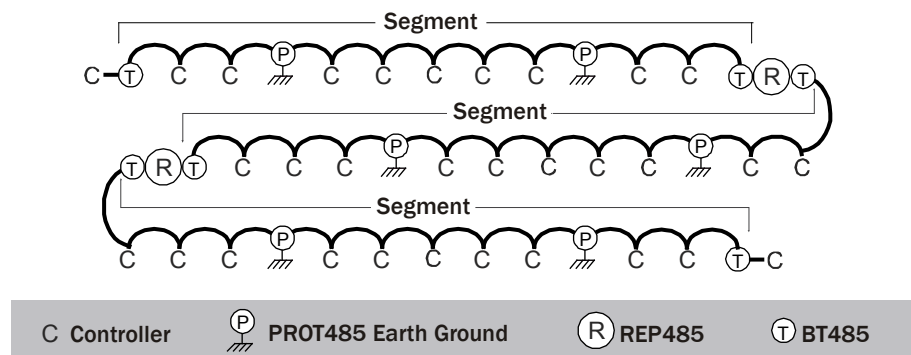
NOTE If the network contains an S6104, M220nx, or UNI controller, the network speed must be 9600 bps or 38.4 kbps.

MS/TP network configurations and requirements
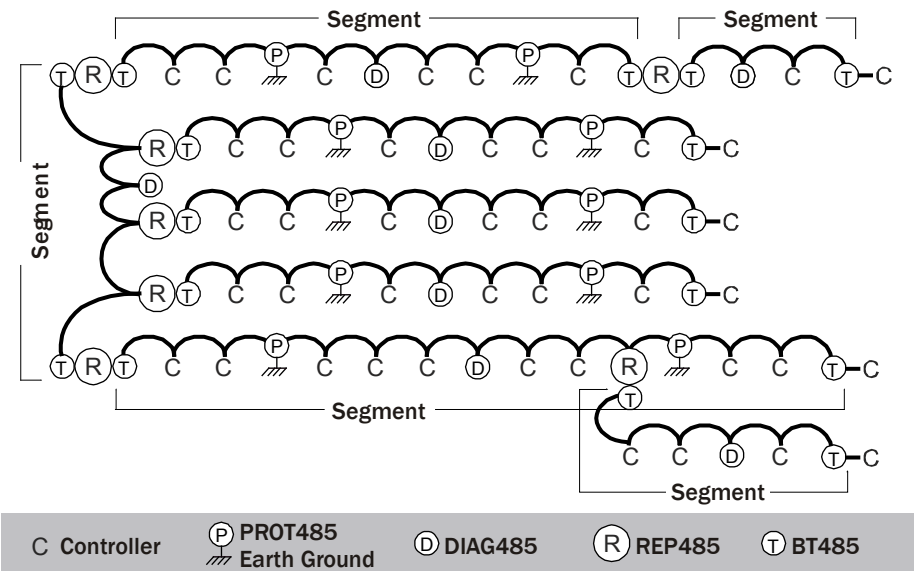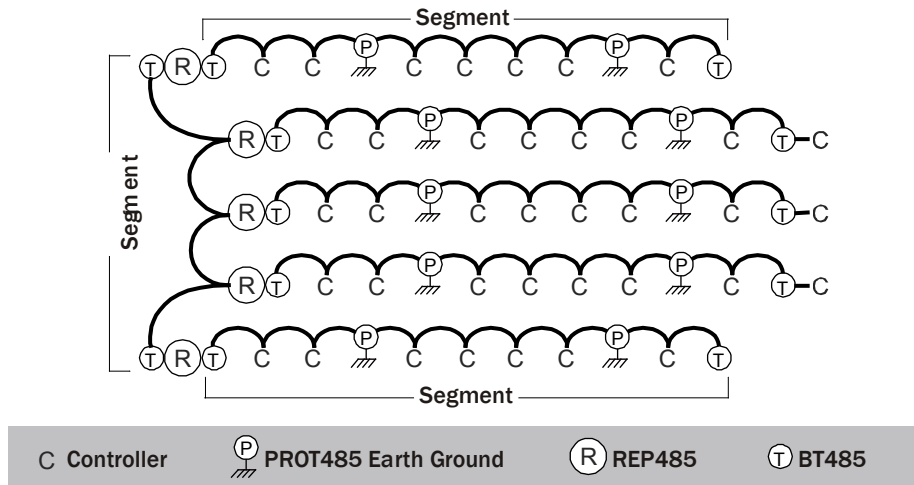
MS/TP network configurations

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

Sample daisy-chain configuration:

C Controller   P PROT485 Earth Ground   R REP485   T BT485

Sample hybrid configurations:

| C Controller | P PROT485 Earth Ground | R REP485 | T BT485 |

| C Controller | P PROT485 Earth Ground | D DIAG485 | R REP485 | T BT485 |

MS/TP network requirements

An entire MS/TP network must have:

- Exec B firmware and driver for each controller

- 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.

| C Controller | Ⓡ REP485 |
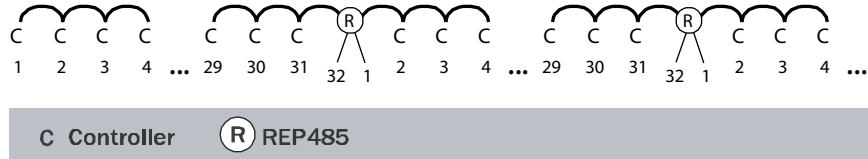
○ A communication packet from one controller to another cannot pass through more than 4 repeaters.

○ 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).

MS/TP network segment requirements

An MS/TP network can consist of multiple network segments. See the samples in *MS/TP network configurations* (page 1). Each segment of an MS/TP 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.

○ If the network segment contains a third-party device that applies bias to the network, you must do one of the following:
- Set the third-party device so that it does not apply bias
- Replace BT485's with 120 Ohm terminators.

○ If a third-party device has its own termination resistance located at one end of the network segment, do not install a BT485 or 120 Ohm terminator at that end of the network segment.

MS/TP network engineering guidelines

MS/TP networks are slower and less efficient than ARC156 networks. MS/TP is a token passing network, meaning each device on the network can communicate only when it has the token. The time needed for the token to cycle through the network is dependent on many factors. Follow the guidelines below to optimize network performance.

Number of controllers

Although an MS/TP network can have up to 99 ALC controllers, the responsiveness of the system decreases as the number of controllers on the network increases. For this reason, ALC recommends that you limit the network to the number of controllers specified below. If you need more controllers than the recommended maximum, consider adding another router and MS/TP network.

Baud Rate	Recommended maximum number of controllers per network
78.6 kbps	50
38.4 kbps	30
19.2 kbps/9600 bps	15

Localized control programs

When possible, put all control programs that exchange information with each other in devices on the same MS/TP network to reduce network traffic through the routers.

BACnet COV subscriptions

Use BACnet COV subscriptions to update a Network Input's value only when the value changes.

To set up a COV subscription:

1   In the network input's **Address** field, enter the address of the BACnet object that the input will subscribe to.

2   Verify that the network input's **Refresh Time** is 31 seconds or more.

3   If the value is analog, set the BACnet object microblock's **COV Increment** to the smallest amount by which the value must change for the BACnet object to notify its subscribers. For example, if you want an Analog Network Input to get the outside air temperature only when it changes by 2 degrees, set the **COV Increment** to 2.

> **NOTE**   The optimal COV increment is high enough to prevent unnecessary updates but low enough to be useful to the control program(s) receiving the updates.

To speed detection of dead device

If a BACnet object's device loses network communication, a network input reading the object's value does not detect the failure until
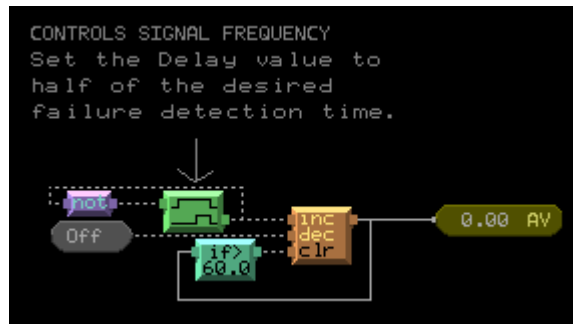
- the network input's next subscription (up to 10 minutes) if using BACnet COV subscription, or

- the **Refresh Time** expires, if polling

You can use a small **Refresh Time** to poll more often, but this can generate unnecessary network traffic under normal conditions.
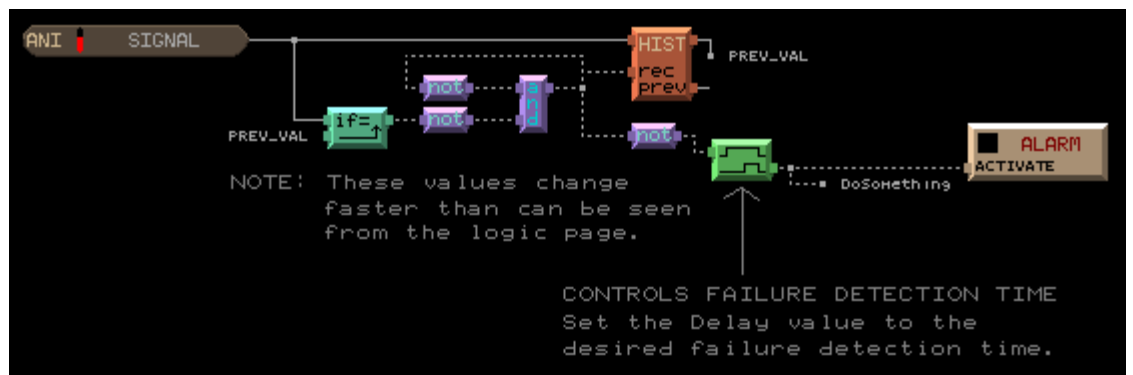
To use the benefits of BACnet COV subscription, but overcome the potential delay in detection of a dead device, send a constantly changing value from the BACnet object's control program to a network input using BACnet COV subscription. If the value stops changing, the network input's control program generates an alarm.

EXAMPLE

The logic in the BACnet object's control program that sends the value. The BACnet Analog Value microblock has a COV Increment of 0.5.

```
CONTROLS SIGNAL FREQUENCY
Set the Delay value to
half of the desired
failure detection time.

  not            inc        0.00  AV
  Off            dec
        if>      clr
        60.0
```

The logic in the network input's control program that receives the changing value. The SIGNAL analog network input's **Address** field contains the address of the BACnet Analog Value microblock sending the changing signal, and the network input's **Refresh Time** is 31 seconds.

```
ANI    SIGNAL                          HIST    PREV_VAL
                          not           rec
                                        prev
          if=    not
PREV_VAL                         not            ALARM
                                                ACTIVATE
NOTE: These values change              DoSomething
      faster than can be seen
      from the logic page.

                          CONTROLS FAILURE DETECTION TIME
                          Set the Delay value to the
                          desired failure detection time.
```

Integrating third-party devices

- Each third-party device counts as 1 controller in the recommended maximum number of controllers per network. The number of third-party points that you communicate with may affect the number of controllers you can put on the network.

- Find out from the the third-party manufacturer's representative if the device supports the following methods that reduce network traffic:

  ○ **BACnet COV subscription**
    This method sends a network message only when the subscribed value changes. If supported, use COV subscriptions for as many points as possible.

    NOTE If the third-party device supports COV but the third-party point's COV increment is so low that the value will be updated more frequently than your system needs, ask the third-party representative to increase the COV increment or set the network input's **Refresh Time** to a number less than 31 to have the network input poll for the value.

  ○ **BACnet Read-Property-Multiple / Write-Property-Multiple** (RPM/WPM) - If COV is not supported, network inputs automatically poll for values. RPM/WPM bundles several BACnet polling requests into one packet. Then the responding controller bundles the responses into one packet.

- If the third-party device does not support COV or RPM/WPM, you can do the following to reduce network traffic:

  ○ Put fewer controllers on the network.

  ○ Reduce the number of points you are requesting values from.

  ○ Use short refresh times only for critical points; set the refresh time to 5–10 minutes for non-critical points.

  ○ Set all network outputs to write only when the value changes.
    1. In WebCTRL, select the equipment in the **GEO** tree.
    2. Select **Properties > Network Points**.
    3. Select the **COV Enable** checkbox for each network output.
    4. If analog, type the amount by which the value must change in the field next to the checkbox.

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.

MS/TP wiring recommendations

Below are ALC's recommendations for MS/TP wiring which are also the wiring 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. **NOTE** 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	**SmokeGard** (SmokeGard PVC) 0.021 in. (0.5334 mm) wall 0.175 in. (4.445 mm) O.D.
	Halar (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	**SmokeGard** 167°F (75°C)
	Halar -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.
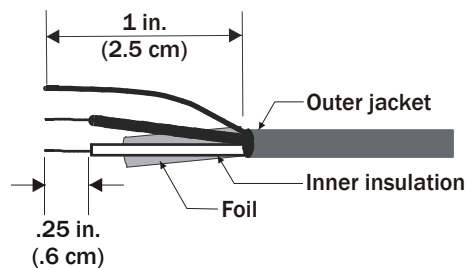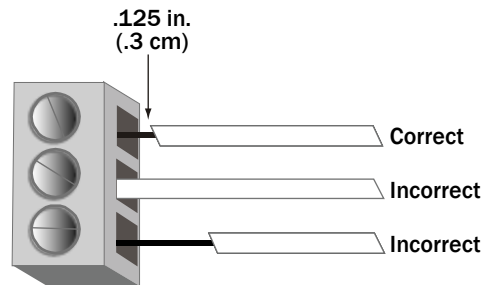

2. Strip about .25 inch (.6 cm) of the inner insulation from each wire.

3. If wiring two cables to the controller, twist together the shield wires from both cables.

4 Insert the wires into the terminal block.
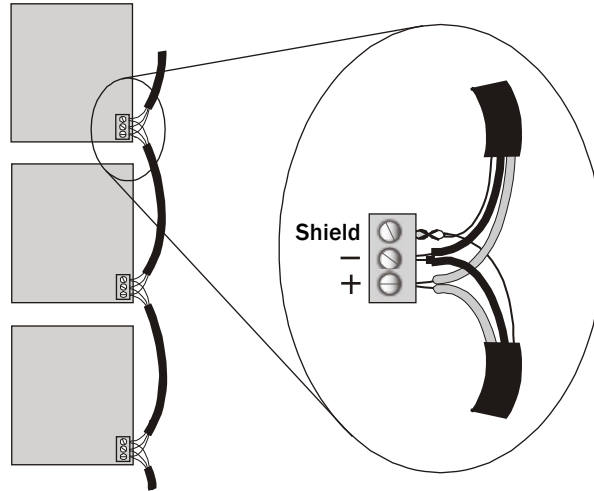
CAUTIONS

○ 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.

To optimize MS/TP network performance

If you feel the network is running slow, you can adjust the driver properties described below for every controller on the MS/TP network.

1 On WebCTRL's **NET** tree, click ⊞ to the left of the controller.

2 Click ⊞ to the left of **Driver**, then select **Device**.

3 Adjust the fields described below.

4 Click **OK**.

Field	Notes
Max Masters	Set this to the highest MAC address (up to 127) on the MS/TP network. **NOTE** If you later add a device with a higher address, you must change this field to that new address.
Max Info Frames	This property specifies the maximum number of information messages a controller may transmit before it must pass the token to the next controller. **CAUTION** Increasing this value allows the controller to transmit more messages while it has the token, but it also increases the overall time it takes for the token to pass through the network. • For a router, set this value to a high number such as 200. • In non-router controllers, use the following formula to calculate this value: [2 - (devices * (.002 + (80/baud)))] / [(600/baud) * devices] = Max Info Frames For example, if the network has 15 devices at 19200 baud, Max Info Frames would be 4. **NOTE** You may need to increase the result of the formula for controllers that need to communicate many values to other devices.

Troubleshooting an MS/TP network

If you do not receive signals from a controller on an MS/TP network:

- Verify that the entire segment uses the recommended cable. See *MS/TP wiring recommendations* (page 7).

- Verify the following aspects of wiring. See *Communications wiring* (page 7).

  - The shields on all controllers and gateways are connected properly. The shield must not touch the metal housing or tie to earth ground.

  - The cable's outer jacket is not stripped more than one inch. If so, the wires may have become untwisted, causing signal reflections.

  - The wires are connected correctly to the terminal blocks.
    Black wire to **Net -**
    White wire to **Net +**
    Shield wire to **Shield**

  - No other communication signal is causing noise or interference. See *Avoiding noise* (page 7).

- Verify that your network meets the *MS/TP network requirements* (page 2) and the *Network segment requirements* (page 3).

- Check for a controller damaged by an electrical surge.

Locating the problem network segment

The network segment most likely to cause a problem is the segment that:

- Contains the most controllers
- Covers the longest distance
- Contains a variable speed controller, spark igniter, or other major noise source

To isolate the problem, 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. If the problems appear on one of the new segments, split this segment in half and repeat this test. Keep splitting the problem segment in half until you identify the cause.

Using an oscilloscope to troubleshoot the network

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

- 1MHz or greater bandwidth
- At least 5 megasamples per second sampling rate
- Battery powered (To eliminate oscilloscope's possible connection to ground.)

When capturing waveforms, use the following settings:

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	Varies per speed
Coupling mode	DC
Trigger level	0.5–1 volt (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.
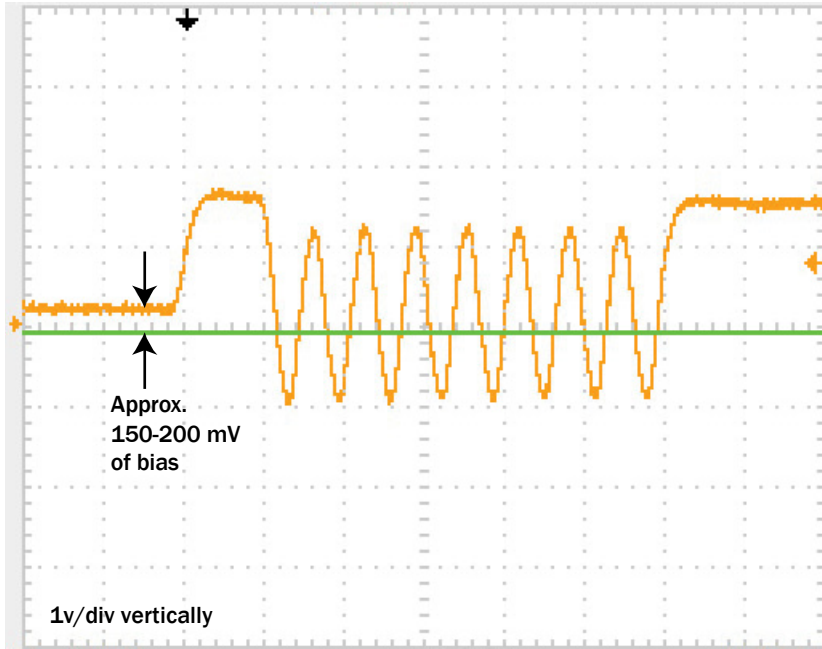
Waveform	Notes

Normal character waveform with short cable and 2 BT485's

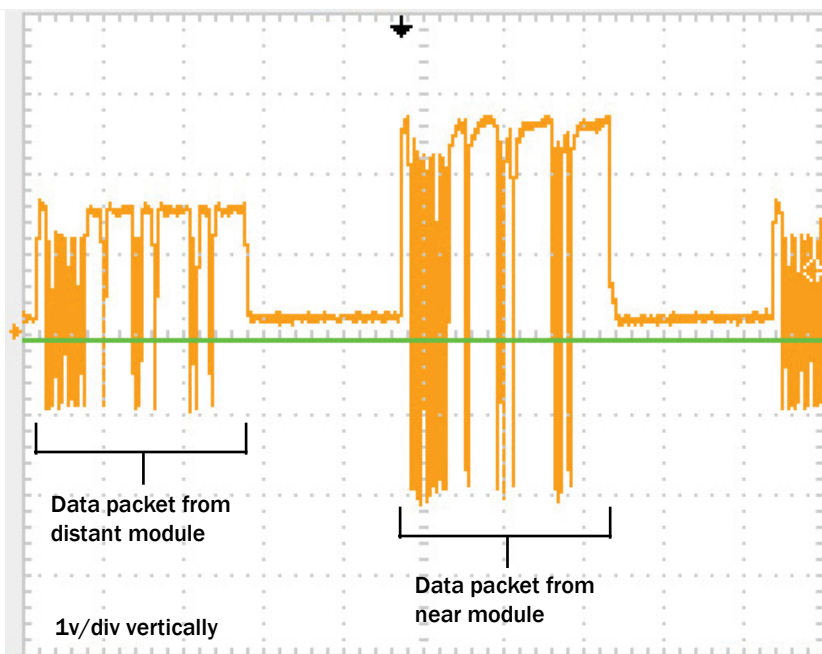Approx. 150-200 mV of bias

1v/div vertically
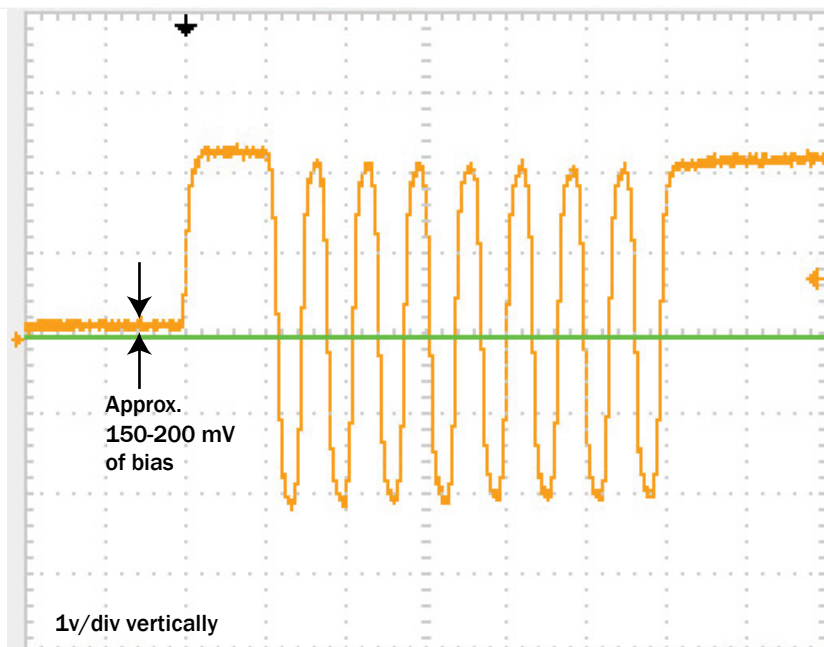
- A normal waveform has sharp vertical transitions at change of bit levels.

- The corners of the waveforms have near-90° transitions.

- For differential connections, the signal is symmetrical above and below the 0-volt line.

- For differential connections, the signal swings from 1–2 volts. If signal swings are <0.75 volt, check for too many terminators on the segment. If the signal swings are >2.5 volts, the segment may not have 2 terminators.
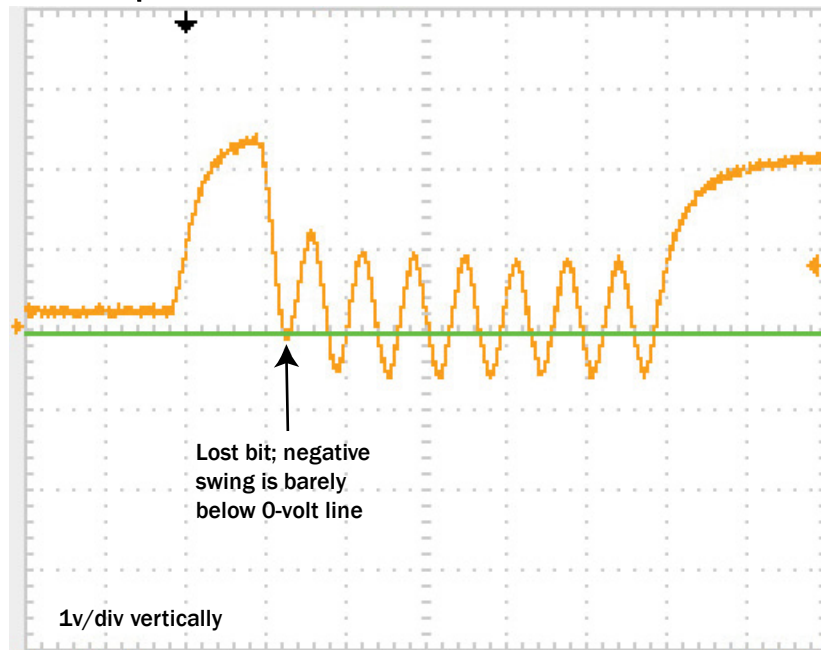
**Normal character waveform
with long cable and 2 BT485's**

Approx.
150-200 mV
of bias

1v/div vertically

**Normal packet waveform
with long cable and 2 BT485's**

Data packet from
distant module

Data packet from
near module

1v/div vertically

Waveform	Notes

Excessive capacitance


Lost bit; negative swing is barely below 0-volt line

1v/div vertically

- 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

>250 mV of bias

negative swing is less than positive swing

1v/div vertically
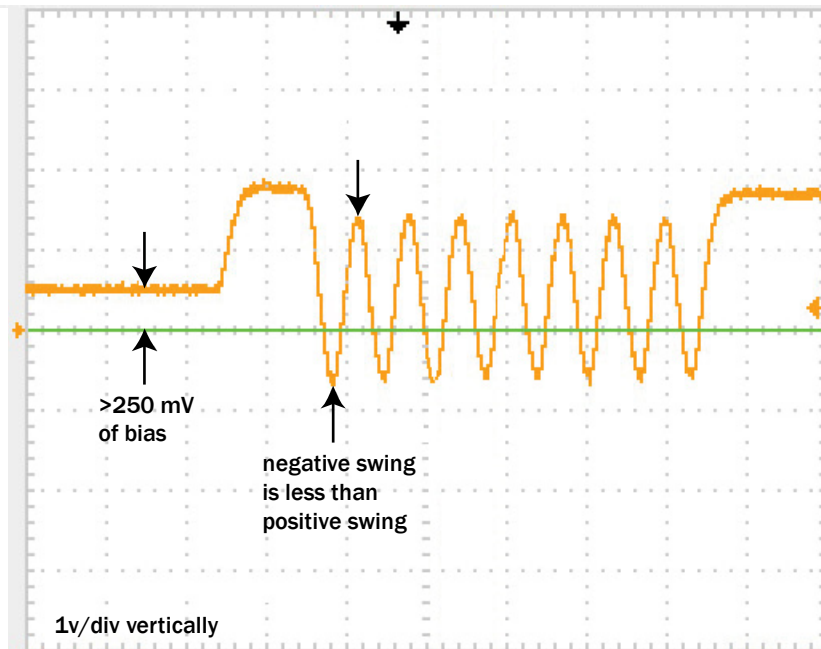
- For differential connections, bias level is incorrectly greater than 0.350 volt.

- 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.