Technical Note 129

RS-485 Troubleshooting guidelines

Identify common issues with communications

Network communication protocols such as BACnet MS/TP or Modbus use the RS/EIA-485 electrical standard for serial communication. These are just two network options available as embedded fieldbus (EFB) on the ACH580 series of variable frequency drives (VFD). Often field installers, technicians, integrator and even tech support encounter intermittent or persistent communication errors. This technical note will detail troubleshooting guidelines using features available within the ACH580 interface.

The following topics are common issues with serial communication that we'll break down into causes, methods to identify and how to correct:

1. UART and CRC errors
2. Isolated devices, 3-conductor wiring
3. Addressing
4. Baud rates
5. Wiring Polarity
6. Biasing
7. Number of devices per network, unit load
8. BACnet Max_Master settings and Token counter

UART, CRC error counters in ACH580 tools for troubleshooting

The ACH580 Primary settings menu organizes the configuration and diagnostics for communications parameters, see Figure 1. Access this menu by navigating to Menu > Primary settings > Communications > Embedded fieldbus > Communication setup or Diagnostics > EFB data from client.

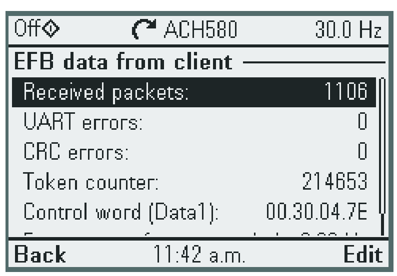

Figure 1: Primary settings, Embedded fieldbus

A universal asynchronous receiver-transmitter or UART is the transceiver type used in serial communication circuits utilized for network communication. The UART transmits data packets with a start and stop bit. If these do not match, an error has occurred and increments the UART errors counter (Parameter 58.11). If this number is increasing rapidly, there are too many data packets being dropped and there will not be successful communication on the link. This is typical when device configuration problems exist on the network.

Cyclic redundancy check or CRC is a value included in a data packet that is checked upon receiving the data and if the value does not match what was transmitted it is expected there was interference in the comm link and increments the CRC errors counter (Parameter 58.12). If increasing quickly there is too much degradation of the data signal, and a device may go offline. Interference is most commonly caused by improper comm cable shielding, grounding, or lack of a reference connection using a 3-conductor cable. Other common names from controls providers for UART or CRC counters might be Bus Health Index, Network Health, Check Sum, etc.

Isolated, 3-wire devices not connected to reference

For more background on isolated versus non-isolated transceivers, see (Technical Note 121: RS-485 Design and install best practices). Noise induced onto a communication network is often electromagnetic or high frequency interference. Cable shielding has a significant impact on limiting EMI if installed properly. That is a continuous connection along the comm cable but only terminated to ground at one end, preferably the supervisor controller. To further reduce the amount of noise into the network, devices such as the ACH580 and ACH180 include isolated transceivers that physically separate the internal circuitry from the communication link, see Figure 2. These devices need to be referenced to one another for the RS-485 serial communication to still function properly.

Three wire, twisted pair, comm cabling is the latest standard for some network protocols but still is beneficial without being a requirement if there are devices with an isolated transceiver. When working with both non-isolated (2-wire) and isolated (3-wire) networks, each should be separately wired and terminated at the supervisory controller. Mixed networks of 2-wire and 3-wire devices are possible but should have the isolated devices referenced to an appropriate ground typically with a small, 100 ohm resistor. ASHRAE BACnet Standard 135-2008 Addendum Y details the variation of networks with diagrams that could be useful when needing to understand or explain making the reference connection for isolated (3-wire) devices.

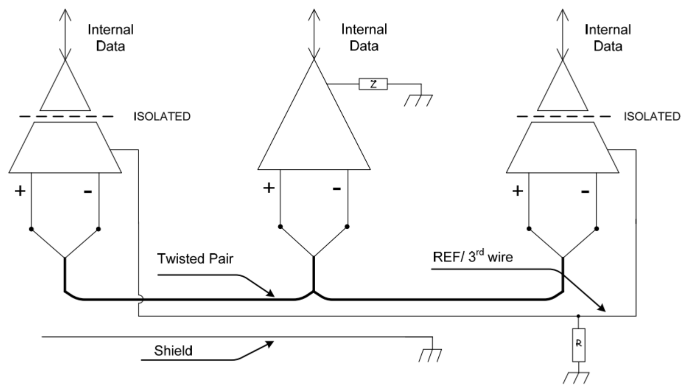

Figure 2: Mixed devices on a 2-wire, twisted pair with shield

<u>How to troubleshoot:</u> while a physical connection, the symptoms seen in the communication link will be intermittent interference to communications going offline. This can be seen by watching the CRC error counter increase. This is commonly observed when a controller is communicating with a VFD while not running. Parameter adjustments are set but once a start command is sent the VFD, several devices or entire network will go offline. If there happens to be a 3-conductor cable pulled for the network, simply connect the reference terminals. If it's a 2-conductor network with mixed devices, the preferred recommendation is to add a 3rd wire for reference and connecting to ground with a small, 100 ohm resistor. Another option, but less immune to interference thus shall be treated as a last resort in troubleshooting, is tying into the comm cable shielding with the resistor back at the controller.

Addressing

Each device on an RS-485 network requires a unique physical device address, commonly called the MAC (media access control) address, so its commands or instructions can be applied to the corresponding client. In the ACH580, this address can be found as Station ID in Primary Settings, see Figure 3, or Node address (Parameter 58.03). When initially connecting devices to a network there may be duplicates as most devices come with a default address. For some protocols, such as BACnet, there are additional Device object IDs, see Figure 4, that need to be unique across an entire site connected to one or more supervisory controllers. Also, see the BACnet Max_Master section for additional addressing troubleshooting.

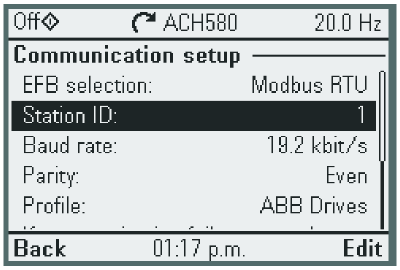

Figure 3: Modbus config

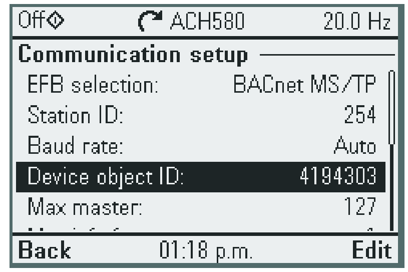

Figure 4: BACnet MS/TP config

How to troubleshoot: using the UART errors counter, watch to see if the number is increasing rapidly. This is potentially a sign of duplicate or incorrect addressing. Check the communication setup for MAC address, Station ID, Node address, Device object ID, Instance ID, etc. If something simple like 0, 1, 127, 254, 4194303 these are likely still at default values. Be sure to refer to a network or controls address schedule to identify the correct address or any unused, available addresses. Some supervisory controllers can automatically assign BACnet Device IDs based on the controllers BACnet Network ID and the device MAC address. Likely this only applies to controllers of the same manufacture as the supervisor. The programming technician then may not realize they need to manually set the Device object ID for 3rd party devices.

When making changes to communications settings, the device may require a reboot (power cycle) to apply the changes. The ACH580 includes a refresh settings (Parameter 58.06) option to apply changes without requiring a reboot, as shown in Figure 5.

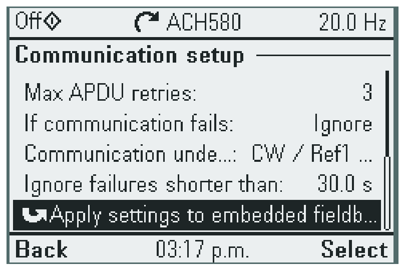

Figure 5: Select Apply settings to make config changes

Baud Rate, auto or manual

Data transmission rate or baud is usually adjustable in most devices and can be used to improve reliability over longer distance communication links. Many manufacturers use a default speed for their devices but not everyone uses the same value. Autodetect is an option to let a device determine baud rate by reading data on the link and setting the Baud rate configuration parameter (Parameter 58.04). If the link baud rate can be determined, this is preferred to set manually and eliminate one variable for communication network troubleshooting, see Figure 6.

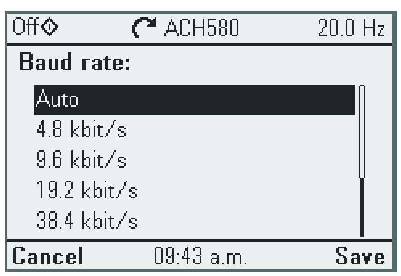

Figure 6: Autodetect or manual baud rate

How to troubleshoot: while the UART error counter might increase because of data packets errors, the whole communication link will also be offline as one device transmitting at a difference baud rate will affect all devices. Confirm the expected link baud rate and adjust in devices accordingly. Note that with Autodetect used as a baud rate setting, if the link baud rate were to change, the Autodetect would have to be selected again as its previously detected baud would be written into the configuration parameter. Again, changes to this parameter do require a reboot or refresh/apply setting changes to the EFB, see Figure 5.

Wiring polarity

Not all serial communication protocols require wiring polarity to be consistent over a network, such as LonWorks. The commonly used Modbus and BACnet MS/TP do need the A(-) and B(+) terminals to match throughout the daisy-chain wiring.

<u>How to troubleshoot:</u> using the UART errors counter you will see the number increasing if one or more devices have reversed polarity wiring on the A(-) and B(+) terminals. The data being transmitted or received is reverse the voltage expected by the device or link. Typically wire color will be used to maintain polarity across the communication link. If this is not clear by comparing the terminal wiring on other devices, simply swap the wiring polarity at your device and determine if the error counter stops increasing or at least slows down significantly, see Figure 7.

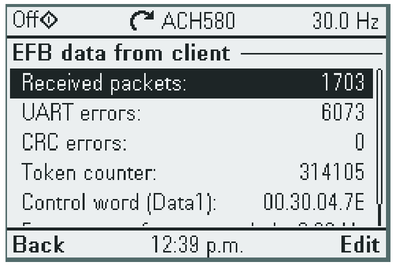

Figure 7: UART error counter increasing

Bias, too much or too little

Known as the failsafe state, having a bias circuit in the RS-485 network pulls the transceivers to known high and low voltages. The failsafe prevents transient voltage levels from being interpreted as network traffic. Newer designed transceivers, like those used in the ACH580, are internally biased and do not require networking biasing. However, legacy products or devices with different transceiver types may still require there to be a bias circuit to ensure this failsafe state.

Biasing may become an issue if no device on the network is set to bias the link or if too many are installed causing potential ground loops or over loading with too many pull up or down resistors. This is possible with internally biased transceivers then adding, or enabling built-in, bias circuits. The number of transceivers will dictate whether network biasing will be required.

<u>How to troubleshoot:</u> check the UART errors counter and if increasing there is potentially problems with the data packets on the network being affected by the amount of biasing. Confirm if any device includes a dip switch that have enabled or disabled biasing resistors. If no biasing is enabled on the comm link, identify a device that could have this biasing resistor enabled, preferably at the end of the comm link. The ACH580 includes a separate dip switch for bias as well as terminator whereas the ACH550 included one dip switch for both bias and terminator. In this case you would need the ACH550 to be the last device on your comm link to act as End of Line terminator as well. Confirm if the controls system manufacture requires biasing through their supervisory controller or other specific devices installed on the link.

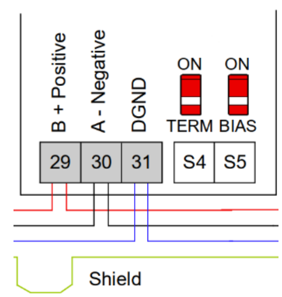

Figure 8: ACH580 bias and terminator dip switches

Number of devices per network

Many controller manufactures will specify the device limit per network link. This is determined using an assumption of transceiver type that will be connected to their controller. The latest BACnet guide specification states “no more than 32 devices on each MS/TP segment.” This refers to the RS-485 standard requiring complaint transceivers to drive a network with up to 32 unit loads (UL). As more devices are added to a communication link it is possible to overload the network with too much load impedance thus increasing voltage drop and reducing signal strength.

However, not all transceivers are a full unit load device. When troubleshooting a network, determine the total number of devices connected to a specific link. If there are approximately 100 devices, the designer may have made the assumption all devices will utilize a quarter-load (1/4) transceiver, or this is what their controller allows. It is possible by adding enough other transceiver unit loads this will cause your network to become overloaded. For example, the ACH580 uses a half-load (1/2) transceiver which would be equivalent to two devices the network is capable of driving. If the network contains existing ACH550 or ACS320 which are full load transceivers, each drive would be equal up to 4 devices on their network count, see Table 1.

Table 1: Theoretical devices count per RS-485 link

Unit Load	Device count	ABB products
Full (1)	32	ACH550, ACS320
Half (1/2)	64	ACH580, ACH480, ACH180
Quarter (1/4)	128	
Eighth (1/8)	256	E-Clipse Bypass

How to troubleshoot: begin by isolating a section towards the end of the communication link to reduce the total number of devices connected to the network. This will bring down the unit load on the network and allow the connected devices to communicate. You can then add back a certain amount of the devices to the network and determine how many can remain connected. Alternatively, the controller manufacture may recommend installing only their devices on one communication link and 3rd party devices on another link. If possible, using existing comm cabling this can be an easy adjustment. Otherwise, consider rewiring for max devices per multiple links.

BACnet Max_Manager (formerly Max_Master)

BACnet MS/TP now called Multidrop Serial Bus/Token Passing describes how each network device can communicate without talking over one another. The manager (formerly master) who currently has the token is the device that can send and receive messages. The BACnet standard requires any manager on the network send a 'Poll for Manager' message out to discover if any new device has been added to the network. Each manager must poll 1 out of every 50 times it receives the token (Parameter 58.13). The polling then checks to see if there is a device at the next address, for example address 10 checks for 11.

This can become an issue when multiple devices have to check multiple addresses for new devices every time they have to poll, requiring overhead bandwidth on the link and can slow communication. To limit the impact of this polling ensure all address are sequential by not skipping address numbers. Only the last device in numerical order then has to check addresses up to 127. Alternatively, you may have an issue discovering new devices if the Max_Master (Parameter 58.41) value is set lower to limit this polling. While a lower Max_Master will reduce the time to finish polling, any devices with addresses greater than the max will not be discovered by the poll and never receive the token to being communicating.

How to troubleshoot: if a device is experiencing slow response times and is the highest address on the link, considering lowering the Max_Master value or adjusting the network to have no skipped addresses. If devices cannot be discovered at their current address, review and confirmed no skipped addresses or raise the Max_Master value to 127 (upper limit).

Summary

Network protocols using serial communication following the RS-485 standard can be a robust and reliable means to connect many devices. Following the install guides for each device and setting the configurations properly will provide a reliable communications network. Physical troubleshooting and investigation using the above features of the ACH580 will guide you through identifying errors in communications network installations. If you are unable to determine certain wiring deficiencies or parameter configurations, consider using other tools to monitor the communications traffic such as Wireshark. Technical Notes available for additional resources are:

- LVD-EOTKN123U-EN – Wireshark for BACnet MS/TP traffic capture
- LVD-EOTKN076U-EN – Testing EFB port on ACH580
- LVD-EOTKN121U-EN – RS-485 Design and install best practices
- LVD-EOTKN044U-EN – ACH580 drive with BACnet
- LVD-EOTKN067U-EN – ACH580 E-Clipse bypass with BACnet