



**ENCCELUM** LIGHTING CONTROLS FOR THE SMART BUILDING

# Network & GreenBus™ Guide

## Energy Control System

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## Introduction

Energy Control System (ECS™) comprises multiple GreenBus™ networks, the Encelium network and the tenant network.

The ECU communicates with sensors and light fixtures via the dedicated GreenBus™. All other communication utilizes a network based on standard 10/100 Base-T Ethernet, TCP/IP & UDP protocols.

## Encelium Network

As shown in Figure 1, an Encelium network comprises of one or more ECUs, one SSU and an energy meter all connected together using a standard Ethernet switch. Within the Encelium network, individual devices are assigned static IP addresses. ECUs can be identified by names (e.g., ECU1, ECU2, etc.) instead of IP addresses.

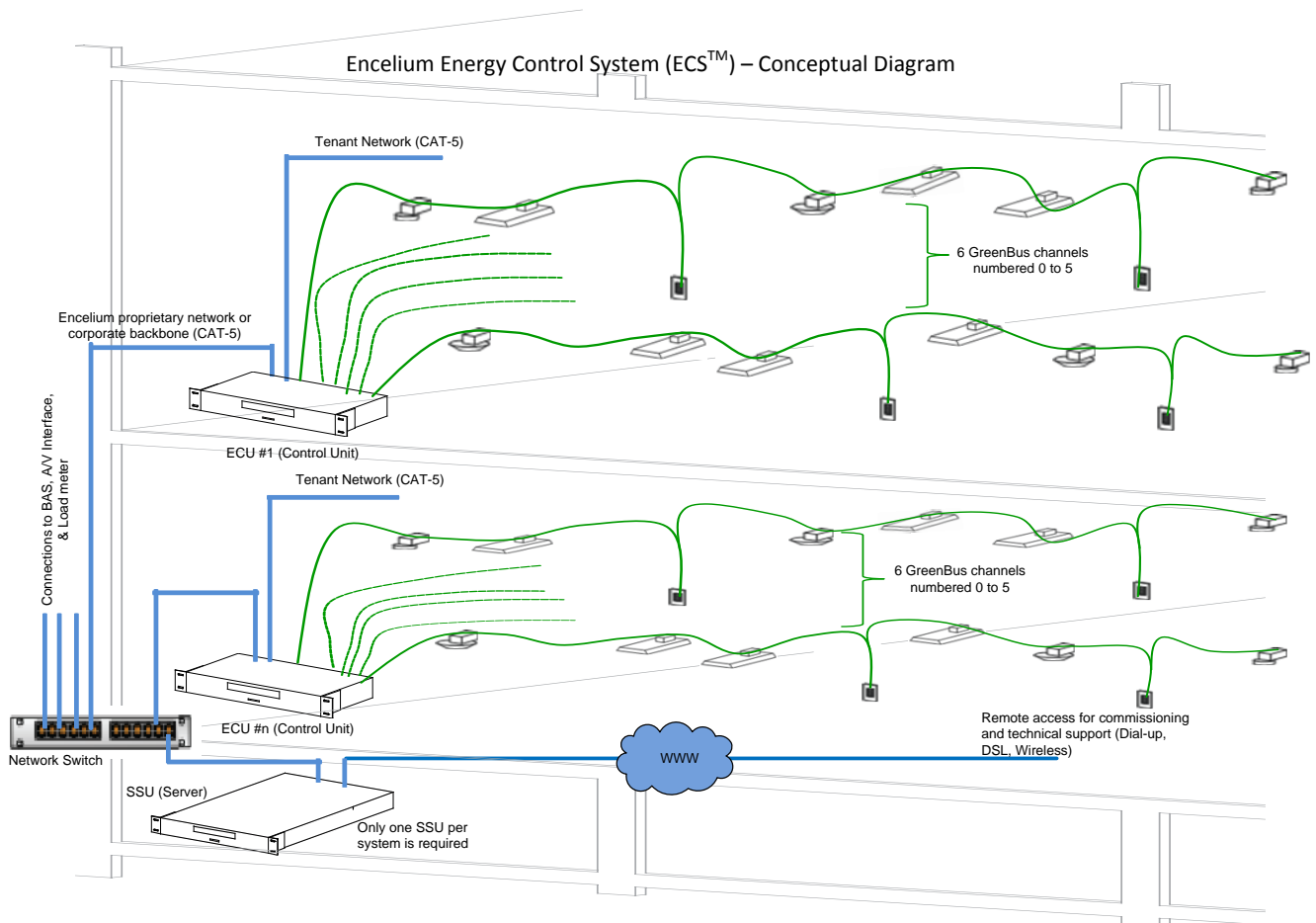


Figure 1: Encelium Energy Control System

An Encelium network can be implemented using dedicated physical cabling or using VLANs.

Two Network Interface Cards (NICs) are installed in each ECU (Energy Control Unit). One of them is used for connectivity with the Encelium network while the other one is used for connectivity with tenant network.

## ECU Communication with tenant LAN

As referenced in Figure 2, both tenant and Encelium ports on an ECU are firewalled. This prevents the Encelium network from initiating communication with the tenant network. ECUs can only listen to and respond to queries (e.g., PCS) from the tenant network.

Encelium network components such as the ECU, SSU and energy meter should all be part of the same IP subnet.

## Multi-Tenanted Building

In a building occupied by multiple tenants, each tenant connects to their respective ECUs via the Tenant Network Interface.

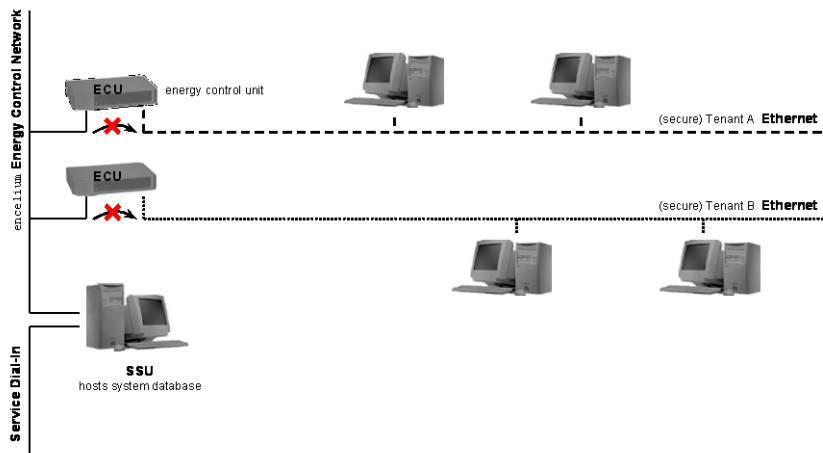


Figure 2: Typical Multi-Tenanted Building Network Architecture

In addition, the tenant network is not visible to unauthorized (if any) Encelium network users. The SSU can be accessed via dial-up or DSL connection.

Communications among multiple ECUs and the SSU are maintained by connecting them all to a switch.



Figure 3: A typical switch

If the network switch has an ‘uplink’ port, be sure not to connect ECU and SSU to this port. This port is reserved for Internet connectivity.

Encelium typically uses the following firewall ports for communication among various networking devices:

For TCP: 9000; 1234; 9101; 9102; 221; 9001; 80

For UDP: 1234

ECS™ Network Interface	Tenant Network Interface
Ports: 1234 TCP/IP 211 TCP/IP 1234 UDP	Ports: 1234 TCP/IP incoming only 211 / 9001 TCP/IP incoming only 1234 UDP (if enabled)
Firewall settings: Access limited to above ports Traffic initiated: typically none	Firewall settings: Access limited to above ports, cannot initiate connections Traffic initiated: none



PCS and PCW applications communicate with the ECS™ via port 80.

### Single-Tenanted Building

Multiple ECUs and a single SSU are connected to the client’s Ethernet network. Connection to the SSU is allowed only through a secure VPN connection to eliminate possible threats to the tenant’s secure data by unauthorized users, etc.

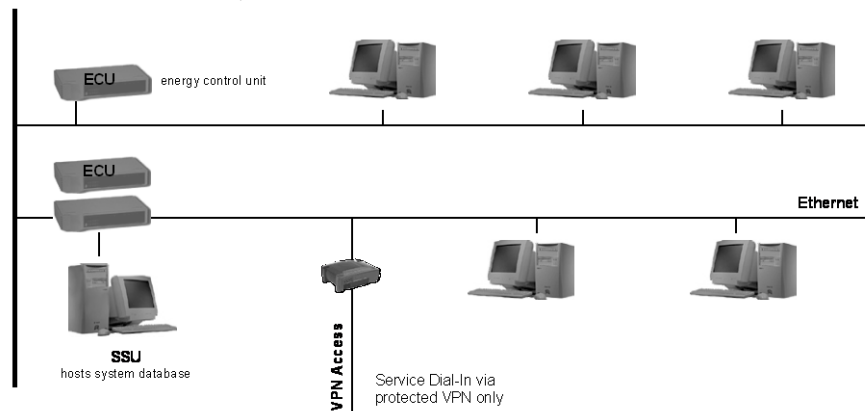


Figure 4: Typical Single-Tenanted Building Network Architecture

The tenant has to provide static IP addresses for Encelium devices (SSU, ECUs and energy meter).

## GreenBus™ Network

Each ECU (Energy Control Unit) channel supports a GreenBus™ network consisting of I/O Modules and Lighting Controllers. Sensors and light fixtures are in turn connected to the I/O Modules.

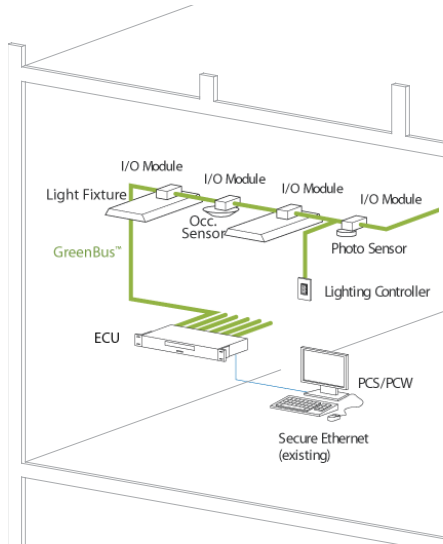


Figure 5: GreenBus™ Network

Each GreenBus™ channel can have 75 addressable nodes. The GreenBus™ cable connects directly to IO Modules, Lighting Controllers and low voltage Relay Modules.

## ECU Connections

The GreenBus™ network cables are connected to ECU ports 0 – 5.

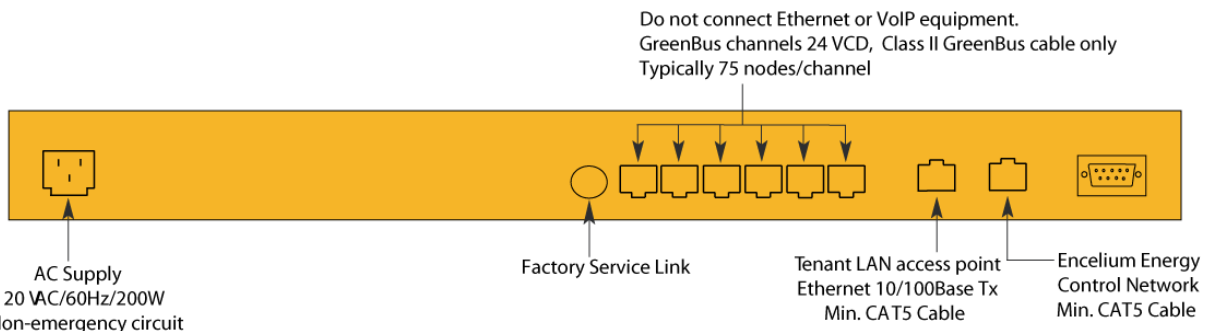


Figure 6: Rearview of an ECU

## GreenBus™ Cable

A GreenBus™ cable is fabricated from 4 pair, UTP (Unshielded Twisted Pair) solid wire Category 3 bulk cable. Cat 5/5e cable is not required but can be used for GreenBus™ cables.

Plenum-rated cable jacket (CSA: “CMP”, UL: “FT6”) must be used whenever the cable travels through an air circulation space. This includes above a false ceiling or below a raised floor.

Internally the cable appears as shown in Figure 7.

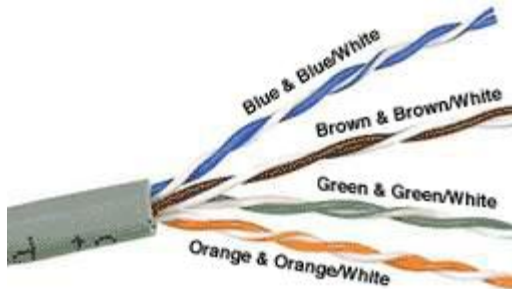


Figure 7: Internal Cable Structure and Color Coding

Inside the cable, there are 8 color-coded wires. These wires are twisted into 4 pairs of wires, with each pair having a common color theme. One wire in a pair is a solid colored wire and the other is a primarily white wire with a matching colored stripe.

The twists are extremely important as they counteract noise and other electromagnetic interference. It is important to wire according to a standard to get proper performance from the cable. The TIA/EIA-568 specifies two wiring standards for an 8-position modular connector such as the RJ-45. The two wiring standards, T568A and T568B, vary only in the arrangement of the colored pairs. There is no difference in connectivity.

Figure 8 depicts the view of the pins after the cable has been inserted into the RJ-45 connectors.

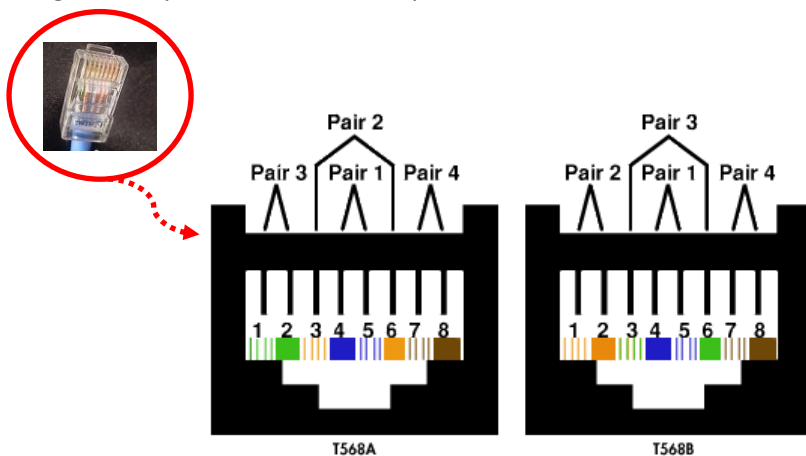


Figure 8: TIA/EIA-568A & TIA/EIA-568B Wiring Standards

## RJ-45 Connectors

GreenBus™ cable ends are terminated with RJ-45 connectors. The RJ-45 connector is an 8-conductor modular connector that looks like a large phone plug. RJ-45 connectors are made for either solid conductors or stranded conductors. It is very important to verify that the plug you use matches the conductor type. It is extremely difficult to tell the difference between the two by visual inspection alone.

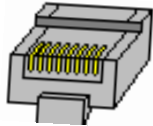


Figure 9: RJ-45 Plug

## GreenBus™ Cable Pinouts

There are two basic cable types. A straight-through cable is used to connect to a hub or switch while a crossover cable is used to connect two network devices in a peer-to-peer fashion without a hub or switch.

**Only straight-through cable connections are used in a GreenBus™ network.**

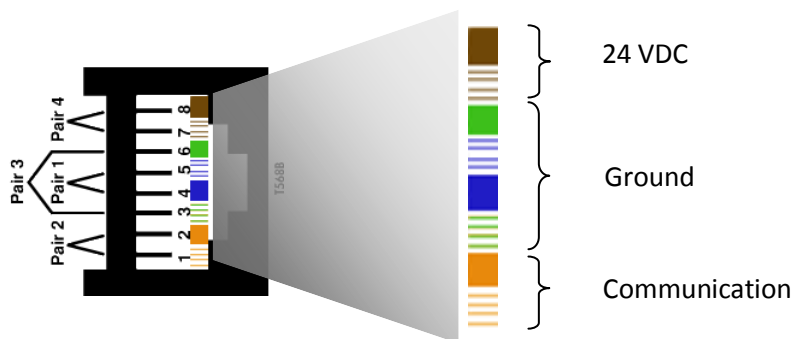


Figure 10: T568B wiring protocol



All pre-fabricated cables are shipped as T568B. Encelium recommends using this standard for on-site GreenBus™ cable fabrication.

## Fabricating GreenBus™ Cable

1. Pull the cable off the reel to the desired length and cut. If you are running cables through conduit, attach the RJ-45 plugs after the cable is pulled.
2. Skin 1 to 2 inches off the cable jacket at one end using a cable stripper (recommended) or a sharp knife. Inspect internal wires for nicks. Start over if nicks are observed.



Figure 11: Stripping the cable jacket

3. Untwist each pair and straighten each wire between the fingers. Do not untwist the pairs inside the cable jacket.
4. Arrange the wires in the proper sequence as shown in Figure 12. Flatten the wires between your thumb and forefinger and then bring the wires together so they run parallel.



Figure 12: Flattened wires

5. Check the wiring sequence one more time holding the wires securely between your thumb and forefinger. Trim the wires to ½" (13 mm) using a pair of sharp wire cutters. Ensure the cut is perpendicular to the parallel wires and all wires are the same length. This is a very critical step. If the wires are not cut straight, they may not all make proper contact.



Figure 13: Cutting the wires

- While continuing to support the trimmed wires with your forefinger, insert them into the RJ-45 connector with the clip facing down in your other hand. Ensure each wire is fully inserted to the front of the RJ-45 connector. The cable jacket should extend into the RJ-45 connector by about 1/2" and will be held in place by the strain relief after the connector has been crimped.



Figure 14: Inserting the cable into the RJ-45 connector

The cable jacket should extend into the RJ-45 connector by about 1/2" and will be held in place by the strain relief after the connector has been crimped.



Figure 15: Extending the cable jacket into the RJ-45 connector

- Verify the wires are in the correct order and that they are pushed completely into the end of the RJ-45 connector and crimp.

Look for the flat ends of the trimmed copper wire against the end of the internal channel.

RJ45 Pin #	Wire Color (T568B)	Wire Diagram (T568B)
1	White/Orange	
2	Orange	
3	White/Green	
4	Blue	
5	White/Blue	
6	Green	
7	White/Brown	
8	Brown	

Figure 16: Crimping the RJ-45 connector

- Repeat steps 1 through 7 for the other end. The wiring protocol is same for both ends of the GreenBus™ cables.
- Use a cable tester to verify proper wiring of the cable.



The maximum length of GreenBus™ cables is limited to 2,500 ft. total per channel. If it is necessary to go beyond 75 addresses or 2,500ft., consult Encelium's Engineering Dept. Ethernet network cables that are used to connect ECUs, SSU and switch are limited to a maximum of 300 ft. in length.

# GreenBus™ Testing with the GBDT

## Operating GreenBus™ Diagnostic Tool

The GBDT (GreenBus™ Diagnostic Tool) supplied by Encelium is used to test all GreenBus™ wiring.

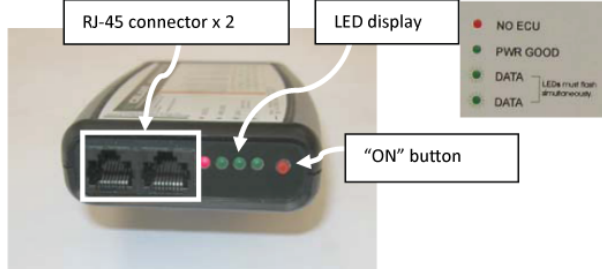


Figure 1: GreenBus™ Diagnostic Tool (GBDT)

Pressing the “ON” button once, turns the GBDT “ON”.

As referenced in Figure 2, with no connections, the red **NO ECU** LED should be “ON” and all other LEDs should be “OFF”.



Figure 2: LED pattern for GBDT turning “ON”

Testing of ECU ports and GreenBus™ channels are performed in this mode.

If GBDT displays an LED pattern other than what is depicted in Figure 2, press the “ON” button for 3 seconds to turn the GBDT “OFF”.

Press the “ON” button again and the GBDT automatically starts testing the GreenBus™ cable connected to it.

## Testing the GreenBus™ channels

To test the GreenBus™ channels:

1. Connect power to the ECU.

The front panel green LED will pulsate slowly. When the green LED begins to flicker quickly, it indicates the ECU is operating.



Figure 3: Front view of ECU

2. Plug the first cable run (channel) to one of the ECU ports (numbered 0 – 5) as shown in Figure 4.
3. Turn the GBDT “ON” by pressing the “ON” button once.

4. As shown in Figure 4, go to the opposite end of the cable run and connect the GBDT to start testing.

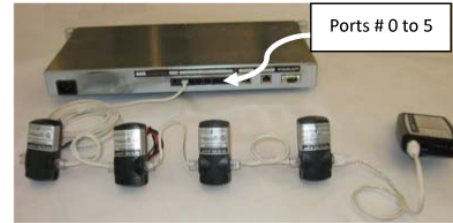


Figure 4: A GreenBus™ channel with four IOMs

If the channel is good, the tool’s green **PWR GOOD** LED lights and the two green **DATA** LEDs will begin to flicker simultaneously as depicted in Figure 5.



Figure 5: LED “good” indication

Any other LED patterns indicate **bad crimping of RJ-45 connectors or GreenBus™ cable discontinuity** problems.

5. As you add devices and cables to the channel, you can continue testing at the end of the channel to ensure that the channel is still working.
6. Repeat steps 4 through 5 for each GreenBus™ channel connected to the ECU.  
The ECU may restart each time.
7. Repeat for each ECU.

## Recommended GreenBus™ Testing Strategy

There are two main approaches to GreenBus™ testing:

1. Test as you go in increments, a few IO modules and cables at a time, channel by channel and ECU by ECU.
2. Install everything on every channel on every ECU first, and then test at the ends of all the channels.

### Encelium recommends testing as you go.

If testing is not performed until the installation is complete, any problem along a GreenBus™ run will cause a fault and then will have to be located. **This takes time, and will probably require going back into the ceiling.**

If testing is performed as you go, the fault can be quickly located while you are in the ceiling and can be corrected immediately.

When you get to the end of the channel run by this process, it will then all be tested and working correctly.

Continued →

### Turning an IO Module "ON"

IO Modules turn "ON" automatically once the GreenBus™ cable they are attached to is connected to an ECU.

To turn "ON" an IO Module manually (turn a fixture "ON") prior to connecting to an ECU, follow the steps below:

1. Connect GBDT to one of the ports of the IO module with an Encelium GreenBus™ cable as shown in Figure 6.



Figure 6: Turning an IO Module "ON"

2. Press the Tool's "ON" button once to turn it "ON".
3. Press it again to set to "IOM Activation" Mode.



Figure 7: LED pattern when setting in IOM Activation Mode

The IO module will be set to the "ON" state.

GBDT's green PWR GOOD LED will flicker for 10 seconds before turning itself "OFF".

## Facts to note when using GBDT

### Protection Mode

ECUs can go into a temporary "protection mode" when numerous devices such as a whole channel or large section of a channel are plugged in.

After any operation that involves the GreenBus™, always wait 15–30 seconds to allow the ECU to recover. Otherwise, you may erroneously assume there is a problem with the ECU.

### ECU Location

When the GBDT is connected in the middle of a channel, one end of the channel terminates at an ECU and the other end does not.

The **PWR GOOD** LED indicates the presence of an ECU on the side that terminates at an ECU and **NO ECU** LED indicates the absence of an ECU on the other half of the channel.

## NO ECU LED

If the GBDT indicates **NO ECU** from both directions, determine where the ECU is connected and whether it is working properly.

## PWR GOOD LED

If the GBDT indicates **PWR GOOD** from both directions, it means there is a closed loop, which is a wiring fault. Identify and correct the closed loop as required. Check the drawings to determine the correct cable setup and correct the closed loop error.



*This situation can arise when data pins of the GreenBus™ cables are connected to ground due to bad crimping, etc.*

## Determining the Location of a Fault

The GBDT can only identify that there is a problem between where it is connected and the ECU.

Use the “divide and conquer” approach to determine the exact location of the fault. First, connect the GBDT approximately half way between the current location and the ECU end of the cable. If the problem continues to appear, move half way again between the current location and the ECU end of the cable. Continue until you find the location of the problem.

Consider the following example (The example shows only 10 I/O Modules, but you may have up to 75 I/O Modules on each of the 6 channels from the ECU).

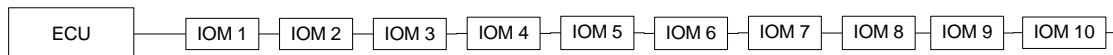


Figure 17: ECU channel with 10 I/O Modules

1. Connect the GBDT at the end of the cable and check for faults. Faults can be anywhere between I/O Module 10 and the ECU.
2. Move to the ECU and check the first connection coming out of the ECU. This helps determine if the problem is with the first cable (“home run” cable) or with the ECU itself. If the first connection has no problems, continue with the next step.

The LED pattern  indicates a connection that has no problems.

3. Calculating from the end of the cable, move halfway back to the ECU. In this case move to I/O Module 5 and test from there.

If the fault no longer appears, you know the problem must lie between the end of the cable (towards IOM 10) and I/O Module 5. Go back half-way toward the end of the cable and test again.

If the fault continues to appear, you know the problem must lie between the ECU and I/O Module 5, so you go back half-way toward the ECU and test again.

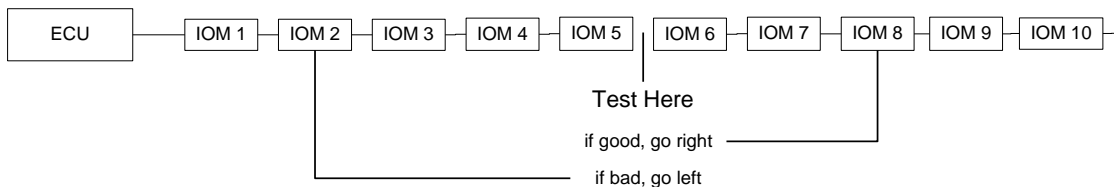


Figure 18: Testing in progress

4. Repeat the process of testing and determining the direction to move until the location where the fault occurs is found.

The fault might be with the GreenBus™ cable or with the I/O Module. It is important both the GreenBus™ cable and the I/O Module attached to it get tested. For more on diagnosing the problem, see “GreenBus™ Testing with the GBDT”.