



Course Workbook

1st Edition



BAS PROTOCOL

— BOOTCAMP —

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Succeed in this course

Over the past year we've created several training courses for our students. As we look back at our past students we've pinpointed two things that make my students successful:

1. Access the program, watch the videos three times, and comment on the videos. The action of watching the videos and engaging with me and fellow students will naturally increase the amount of information you retain.
2. Work through this workbook. This workbook was designed to help you retain key pieces of information that have a direct impact on your performance as a BAS professional. As you move through each lesson I will ask you questions in the workbook that will help you to further expand your knowledge.

Don't skimp on these two actions. The reality is learning anything takes work. Fortunately for you, I've condensed that learning into the shortest time possible.

When you follow the three steps above you will see massive results as you work through this course.

Remember, I am here for you at any time via the discussion section and live office hours.

I look forward to hearing about your success story.

To your success,

-Phil



Module 1: Protocol Overview

In this module we are going through the basics of what protocols are. Here is the lesson for this module.:

- Lesson 1: Protocol Overview

Understanding protocols is a key step in your BAS career. Whether you want to be a programmer, lead service technician, or even a product designer.

Protocols are the key.

After all, protocols are what dictate how, when, why, where, and what BAS devices communicate!

Master protocols and you will have mastered the language of building automation!



Lesson 1: Protocol Overview

Lesson Objectives:

- Describe what protocols are
- Explain we use protocols

What do protocols establish?

Why do we use protocols?

What do you need to understand about protocols?

What are the three key points about protocols?



MODULE 2: BACnet

In this module we will be diving into the granddaddy of protocols BACnet!
The lessons in the module are:

- Lesson 1: BACnet Overview
- Lesson 2: BACnet Devices and BTL
- Lesson 3: BACnet Objects
- Lesson 4: BACnet Properties
- Lesson 5: BACnet Priority Array
- Lesson 6: BACnet Services
- Lesson 7: BACnet/IP
- Lesson 8: BACnet MS/TP
- Lesson 9: BACnet Troubleshooting

BACnet is the defacto standard for BAS. BACnet has been around for decades now and the majority of BAS that are installed in the field utilize some form of BACnet.

That is why most of this course will focus on BACnet.



Lesson 1: BACnet Overview

Lesson Objectives:

- Describe the parts and pieces of BACnet networks
- Explain how communication takes place throughout a BACnet network
- Identify the parts and pieces of a BACnet network

What is a BACnet device?

What does every BACnet device need to have?

Why do we ask for static IP addresses for BACnet devices?

What is the BACnet hierarchy?

When does an object's ID not need to be unique?

Why would you want to use common object id's?



What are BACnet properties used for?

How are properties communicated between devices?



Lesson 2: BACnet Devices and BTL

Lesson Objectives:

- Explain the different kinds of BACnet devices
- Describe the process of client-server BACnet communication
- Identify BTL listings
- Explain BTL's impact on a BAS device

What makes a BACnet server device unique?

How is BACnet data sent from a supervisory device to a user interface?

When a controller wants to read a property from another device how does it do it?

Why would you write a value to a BACnet client device?



What is BTL? Why does it exist?

What is a BACnet device profile?

What are the 5 categories for BIBB's? What is their purpose?

How do you look up a BTL profile of a device?

What is the PIC's statement? What is the BTL listing?

How do you determine if a BIBB is a client or server block?



Lesson 3: BACnet Objects

Lesson Objectives:

- Describe what BACnet objects are
- Explain how objects are used

What is a BACnet object?

What two things do BACnet objects have?

Why do some objects not have the same properties as other objects?

What is the difference between objects and points?

What is the difference between the calendar and schedule object?

What is the major difference between ASC and AAC devices?



Lesson 4: BACnet Properties

Lesson Objectives:

- Describe what properties are
- Explain how properties are used?

What are BACnet properties?

What are the three standard BACnet properties?

What is the difference between required and optional properties?

Where would you go to find out more about properties?

What are some of the properties you would find in the device object?



Why is it important to know what objects and services are supported in devices? How could you find this information out?

What is an APDU?

What is APDU timeout?

What is the difference between out of service and reliability?

Why is it important to understand the min and max range of properties?

What is the purpose of a status flag?

What are some of the common properties in schedule objects?



Why is the schedule default property so important?

Where do you store your occupancy objects?

What is the effective period?

What is purpose of a buffer in a trend object?

What is the difference between the weekly schedule and exception schedule?

How do trends work?

What is purpose of a buffer in a trend object?



What is the difference between a batch and stream?

What is the first thing you should check when your trends aren't working?

What are the common Trend object properties?

How is the way Trends send data chosen?

Why is it important to understand what property we are working with?



Lesson 5: BACnet Priority Array

Lesson Objectives:

- Describe what the priority array is
- Explain how the priority array works

Where are the main places we will use priority arrays?

What is the priority array?

How is importance determined on the priority array?

What is a null array? What writes to your present value if you have a null array?

What is the purpose of an operator override?



Why do you need to be especially careful with the priority array found inside value objects?

What is the difference between a zero value and a null value in the priority array? Why is this difference important?



Lesson 6: BACnet Services

Lesson Objectives:

- Explain what BACnet services are
- Describe the most common BACnet service types

What is a service?

How do BACnet clients and servers work with services?

Can a client have server capabilities?

Who is responsible for BACnet response data?

What are the two forms of services?



What are the two forms of acknowledgments?

What are the three most common service categories for BACnet?

What services are involved with alarming?

What are the two forms of CoV notifications? When do you use each one?

How does CoV work?

Why is important to have CoV thresholds set properly?

How are subscribed and unsubscribed CoV services different?



What are the 3 types of reading services?

What are the 2 types of writing service?

Why are the TimeSynchronization services important?

What is the difference between the Who-is and Who-has services?

Why do we want to use a range in our discovery searches?

How does the GetAlarmSummary service work? How do you clear alarms?

How are objects created and deleted?



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Lesson 7: BACnet/IP

Lesson Objectives:

- Explain how BACnet/IP is used
- Describe how BACnet/IP communication works

What are the three unique BACnet layers?

What is the difference between NPDU's and APDU's?

What are the BVLC and BVLL? Why are they used?

What will every BACnet/IP Device have?

How will two BACnet devices on the same subnet communicate?

Why would the NPDU be empty on local communication?



How do we read through a BACnet/IP message in Wireshark?

Where would we find the source and destination values in a BACnet message?

Where would we see what service is being used in a BACnet message?

What is a BBMD?

How does a BBMD work?

What is the purpose of a BDT?

What are BACnet nodes?



What are the two kinds of BACnet/IP segments?

What is a BACnet network? Is a BACnet network constrained to a specific subnet?

How is the BACnet address calculated?

Why are conflicting BACnet UDP ports bad?

What are the three kinds of BACnet broadcasts?

Why do we use BBMD's?



Lesson 8: BACnet MS/TP

Lesson Objectives:

- Describe the characteristics of BACnet MS/TP
- Explain how BACnet MS/TP works

What is a daisy chain?

Why is BACnet MS/TP called a serial protocol?

What are the wiring requirements and limitations for BACnet MS/TP?

What happens to your max segment length as you increase the baud rate?

How many times can you extend segments with repeaters?



What is baud rate?

What are the two baud rates that MS/TP must support?

Why should all devices on a segment use the same baud rate?

What are the limitations for MS/TP addresses?

How are MS/TP devices addressed?

What are the three address ranges with MS/TP?

What is the purpose of end-of-line resistors?



Why are EoL dip switches dangerous?

What is a BACnet Master device? What capabilities does it have?

What is a BACnet slave device? What capabilities does it have?

What are the 8 BACnet MS/TP frames?

What is the purpose of the BACnet MS/TP Token?

Why would you want to address your MS/TP devices sequentially?

What are the 9 states a BACnet MS/TP device can be in?



What are the two most common wiring patterns for BACnet MS/TP networks?

What is a T-Tap? Why are they bad?



Lesson 9: BACnet Troubleshooting

Lesson Objectives:

- Describe the most common issues with BACnet
- Explain how to address each one of the common issues

What issue is universal across the different types of BACnet?

What are the two common issues with BACnet/IP? How do you resolve these issues?

What are the most common BACnet MS/TP issues?

How do you determine if BACnet MS/TP issues exist?

How do you resolve each BACnet MS/TP issue?



MODULE 3: LON

In this module we are going to discuss LON. The lessons in the module are:

- Lesson 1: LON Overview
- Lesson 2: Neuron Chips and Nodes
- Lesson 3: LON Objects
- Lesson 4: LON Topology Overview
- Lesson 5: LON Database and Plugins
- Lesson 6: LON EIA-852 and FT-10

Depending on who you talk to you will get varying points of view around LON. In Europe LON still has a very active presence. In the US LON is a dying breed.

However, that doesn't mean that LON is unimportant. No matter where you are in the world LON still has an extensive presence. That is why it is important for us to study LON.



Lesson 1: LON Overview

Lesson Objectives:

- Explain what LON is
- Describe the different parts of LON

What does LON stand for?

What is the big difference between LON and other protocols?

How do nodes communicate with the LON network?

What is a LON channel?

What are the two main channels of LON?

How is the LonTalk protocol similar to BACnet and different than BACnet?



What is the Neuron chip? Why is it important to LON?

What is the LNS OS? What is the purpose of the LNS OS?



Lesson 2: Neuron Chip and Nodes

Lesson Objectives:

- Explain how Neuron chips work
- Describe the LON node

What is the purpose of the Neuron chip?

What is a Neuron ID? How is it determined?

What are LON Nodes? What are the “two types of nodes”?

What is the purpose of binding?

How are nodes addressed? What is the difference between the Node address and the neuron ID?



What are the two types of LON controllers?

What is the downside of the free programmable controller?

What is the purpose of the XIF file?

What are the two areas you need to understand when doing a LON retrofit?



Lesson 3: LON Objects

Lesson Objectives:

- Describe the different kinds of LON objects

What is a LON Object?

What are the 6 basic LON objects?

What are the two software LON objects?

How many NV's can you have on a node?

What will happen to a NV if the controller resets?

What is the difference between NVI's and NVO's? When would you use each one?



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What are SNVT's?

What are SNVT's used for?

What is a binding?

What are CP's?

What are the differences between CP's and SNVT's?



What are LonWork Functional Profiles?

What is the purpose of a Functional Profile?



Lesson 4: LON Topology Overview

Lesson Objectives:

- Describe what makes up a LON network
- Explain how LON Networks work

What are the four physical components that make up a LON network?

What is a LON segment? How is it wired?

What are the limitations to using repeaters in LON?

What are the four reasons for using routers?

What are the two kinds of routers? What are the capabilities of each one?



What is the logical structure of LON networks? What are the three main constructs?

What is the purpose of a LON domain? What are the limitations of domains?

What is the purpose of subnets? What are the limitation of subnets?

What is the purpose of a channel?

What is the purpose of a group? What are the limitations of groups?

When can groups have unlimited nodes?



What are the four forms of LON communication?

Provide an example of each form of LON communication.



Lesson 5: LON Database and Plugins

Lesson Objectives:

- Describe the purpose of the LNS database
- Explain how to create and rebuild LNS databases

What is the purpose of the LNS database?

What are the steps for commissioning an LNS network into a database?

What are the four reasons we want to have an LNS database?

What are the two databases within the LNS database?

What is the purpose of each database?



What is the purpose of the LNS server?

How do you interface a supervisory device with an LNS network?

What are three reasons the LNS database important?

What are the four-steps for creating an LNS database?

Why would you synchronize a database? What are the two kinds of synchronization?

How do you recover an LNS database?

What do we need to be aware of when recovering databases?



How do you program LON controllers?

What is the purpose of LON plugins?

How do you setup a LON plugin?

What do you need to do with a programmable controller to get an XIF?



Lesson 6: LON EIA-852 and FT-10

Lesson Objectives:

- Describe how the LON architecture works
-

What are channels?

How do channels relate to segments and subnets?

What is FT-10?

What is EIA-852?

How can we connect between two domains?



Do subnets and channels need to be unique across multiple subnets?

When can you have 64 devices per FT-10 segment? When can you have only 32 devices?

What is the purpose of the LNS Middleware stack?

How would a supervisory device connect to a LON network?



MODULE 4: Modbus

In this module we are going to the Modbus Protocol. The lessons in the module are:

- Lesson 1: Modbus Overview
- Lesson 2: Modbus Objects and Functions
- Lesson 3: Modbus/TCP
- Lesson 4: Modbus/RTU

When you think of Modbus what comes to mind? If you have been in the field for a while you're probably thinking of meters and elevators. Modbus was originally an industrial protocol, but it has found adoption within the BAS space because it is less costly to construct sensing devices utilizing the Modbus protocol.

While Modbus hasn't substantially changed over the past decade it is still important for us to explore the protocol as it is still a widely used protocol.



Lesson 1: Modbus Overview

Lesson Objectives:

- Explain what Modbus is
- Describe how Modbus works

What are ADU's and PDU's?

What is the purpose of the Modbus function code?

How does the Modbus client-server architecture work?

What are the two-main protocol stacks for Modbus?

How does Modbus messaging work?

How are message errors dealt with?



What are the four Modbus types? What does each one do?

Why is it important to understand function codes?



Lesson 2: Modbus Objects and Functions

Lesson Objectives:

- Describe what the four Modbus objects are
- Explain how Modbus functions work

What are the two forms of object addressing Modbus supports?

Why is important to refer to manufacturer documentation when using logic blocks?

What are the two writeable object types?

What happens if the data for an object stretches across two registers?

What is an array bit?



What are the three categories of functions?

What are the three function code ranges?

Why is understanding the function codes and their corresponding numbers important?



Lesson 3: Modbus/TCP

Lesson Objectives:

- Describe what Modbus/TCP is
- Explain how Modbus/TCP works

How are Modbus/TCP devices addressed?

When should you use a static IP address with Modbus/TCP?

What is the difference between Modbus Servers and Clients?

What are the three primary purposes of the MBAP header?

What is the purpose of TCP?

What port does Modbus use?



How does the TCP handshake work?

How is a TCP connection closed?

What is a TCP stream?

How can you view a TCP stream?



Lesson 4: Modbus/RTU

Lesson Objectives:

- Describe what Modbus/RTU is
- How does Modbus/RTU work

How is Modbus/RTU addressing different from BACnet MS/TP?

How do slaves and masters work in Modbus/RTU?

What are the wiring requirements for Modbus/RTU? Why do these requirements matter?

Can you T-Tap Modbus/RTU devices? Why would you want to avoid these?

What are the two required speeds Modbus/RTU is required to support?



How do you indicate the end-of-line with Modbus/RTU?

How is Modbus/RTU Master-slave communication different then BACnet MS/TP?

What are the two types of Modbus/RTU messages?

What is the CRC field on the Modbus/RTU? Why does it matter?

What are the 5 settings that you need to configure for Modbus/RTU to work?