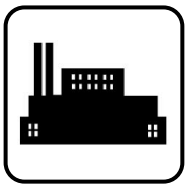
Protocol Operation

APM603 Communication Protocol



Controller:

APM603

Includes

Modbus®
SNMP
BACnet®

KOHLER®

TP-7151 9/19

Table of Contents

IMPORTANT SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions. SAVE THESE INSTRUCTIONS.

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

⚠ DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death, or substantial property damage***.

⚠ WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death, or substantial property damage.***

⚠ CAUTION

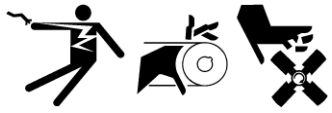
Caution indicates the presence of a hazard that ***will or can cause minor personal injury or property damage.***

NOTICE

Notice communicates installation, operation, or maintenance information that is safety related but not hazard related.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely. The decals are shown throughout this publication to improve operator recognition. Replace missing or damaged decals.

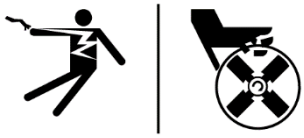
Accidental Starting

⚠ WARNING	**Accidental starting.** **Can cause severe injury or death.** Disconnect the battery cables before working on the generator set. Remove the negative (–) lead first when disconnecting the battery. Reconnect the negative (–) lead last when reconnecting the battery.
	

Disabling the generator set. Accidental starting can cause severe injury or death. Before working on the generator set or equipment connected to the set, disable the generator set as follows: (1) Press the generator set off/reset button to shut down the generator set. (2) Disconnect the power to the battery charger, if equipped. (3) Remove the battery cables, negative (–) lead first. Reconnect the negative (–) lead last when reconnecting the battery. Follow these precautions to prevent the starting of the generator set by the remote start/stop switch.

Hazardous Voltage/Moving Parts

DANGER 	**Hazardous voltage.** **Will cause severe injury or death.** Disconnect all power sources before opening the enclosure.

DANGER 	**Hazardous voltage. Moving parts.** **Will cause severe injury or death.** Operate the generator set only when all guards and electrical enclosures are in place.

This manual provides instructions for using the following communication protocols with the APM603 controller:

- Modbus® RTU and TCP
- Simple Network Management Protocol (SNMP)
- BACnet®

Information in this publication represents data available at the time of print. Kohler Co. reserves the right to change this literature and the products represented without notice and without any obligation or liability whatsoever.

Read this manual and carefully follow all procedures and safety precautions to ensure proper equipment operation and to avoid bodily injury.

Related Materials

The controller Operation Manual and the Commissioning and Setup Manual provide information about setting up the controller to enable remote communications and programming. It also provides information about equipment operating limits, specifications, and functions. See Figure 1 for a list of related documents.

Consult the specification sheets, accessory installation instructions, service bulletins, application notes, drawings, and other applicable literature for additional information on equipment operating limits and specifications. Contact your local distributor/dealer or the equipment manufacturer to obtain applicable literature.

Document	Part Number
Generator Set Installation Manual	TP-5700
Operation Manual, APM603	TP-7100
Commissioning and Setup Manual	TP-7131

Figure 1 List of Related Materials

Service Assistance

For professional advice and conscientious service, please contact your nearest Kohler distributor or dealer.

- Visit the Kohler Co. website at KOHLERPower.com.
- Look at the labels and decals on your Kohler product or review the appropriate literature or documents included with the product.
- Call toll free in the US and Canada 1-800-544-2444.
- Outside the US and Canada, call the nearest regional office.

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North Asia Regional Office
Tokyo, Japan
Phone: (813) 3440-4515
Fax: (813) 3440-2727

1.1 Introduction

The APM603 controller supports Modbus RTU and Modbus TCP communication.

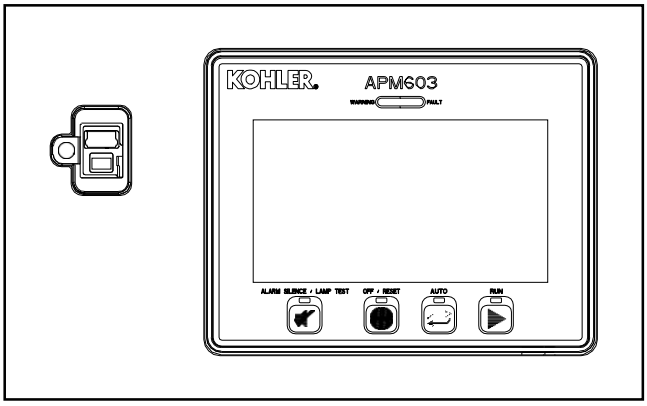

Figure 2 APM603 Controller

1.2 Modbus/RS-485 Serial Communication:

The APM603 controller:

- Supports industry-standard Modbus RTU protocol.
- Uses RS-485 connections to connect to a Modbus master with a single connection or within an RS-485 network.
- Uses standard baud rates of 9600, 19200, 38400, 57600, or 115200.

The controller communicates using Modbus as a slave connection with the Modbus master initiating the communication. The controller seeks the parameters and diagnostic information then responds back to the Modbus master. In addition, the controller accepts information to alter controller parameters including generator set starting and stopping.

The APM603 has two RS-485 ports:

- One isolated for general use
- One non-isolated for use with an RSA III. If not used with an RSA III it can be used for general use but should be isolated.

Note:
Only one Modbus master can be connected to each Modbus RTU port on the controller.

The Modbus master polls slave devices for data. Controller devices are slaves. Examples of master devices are a personal computer running a Modbus driver and the RSA III remote serial annunciator. See Figure 4 and Figure 5 for examples of the possible configurations.

Note:
Install communication conductors in raceways, cables, or conduit separate from AC power conductors.

1.2.1 Serial Settings

Kohler® controllers use the settings shown in Figure 3.

All devices in a network must use the same baud rate.

Property	Setting
Data Bits	8
Parity	None
Stop Bits	1

Figure 3 Serial Settings

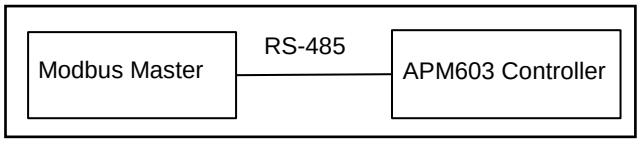

Figure 4 Single RS-485 Connection

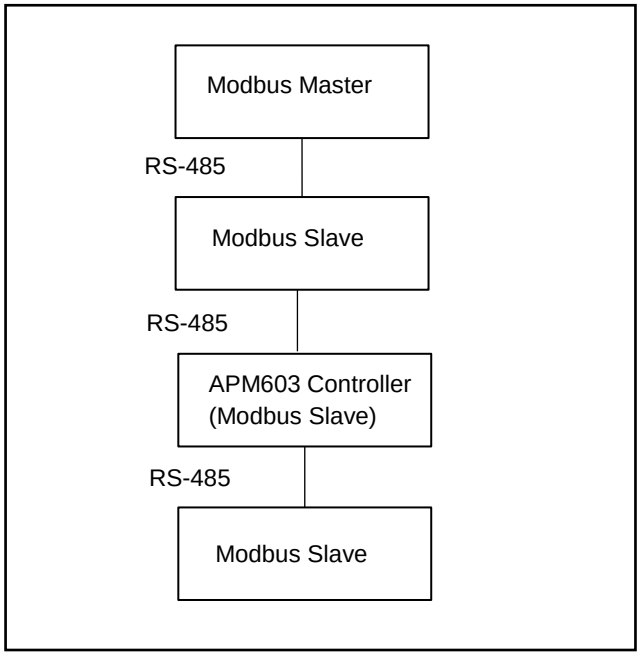

Figure 5 RS-485 Network

1.2.2 Modbus RTU Connections

Use RS-485 cable for Modbus RTU connections Belden #9841 or equivalent shielded, twisted pair cable is recommended for indoor installations. Ensure that the cable is rated for the application. The maximum cable length is 1219 m (4000 ft.).

Note:
Circuit isolation is recommended for installations that may be exposed to electrical noise. See Appendix B, Noise and Wiring Practices.

Use the following procedure to connect the hardware. Observe the safety precautions. See Figure 7 and the network connection diagram GM62554.

Connection Procedure

1. Press the OFF button on the controller.
2. Disconnect the power to the battery charger, if equipped.
3. Disconnect the generator set engine starting battery(ies), negative (-) lead first.
4. Turn off and disconnect the power to all devices in the system.
5. Connect to the RS-485 communication port on the customer connection terminal block as shown in Figure 7.

   Note:
   See the generator set wiring diagram to identify the customer connection terminal block.
6. Verify that the controller is OFF.
7. Reconnect the generator set engine starting battery, negative (-) lead last.
8. Reconnect power to the battery charger, if equipped.

1.3 Modbus/RJ45 Ethernet Connections

The APM603 controller:

- Supports Modbus TCP protocol.
- Connects directly to an Ethernet network. See Figure 6 for an example of a possible Ethernet network configuration.

Connect the network cable to the RJ45 port on the Ethernet module shown in Figure 7.

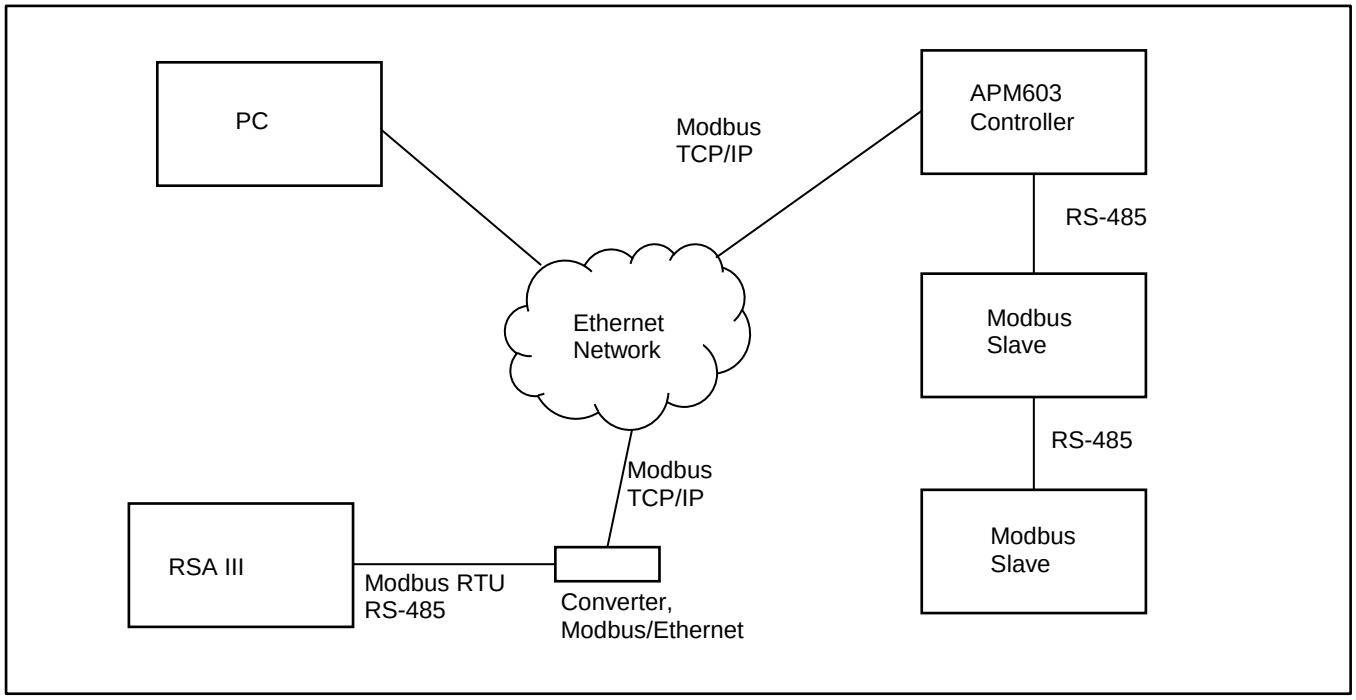

Figure 6 Ethernet Network Connection Example

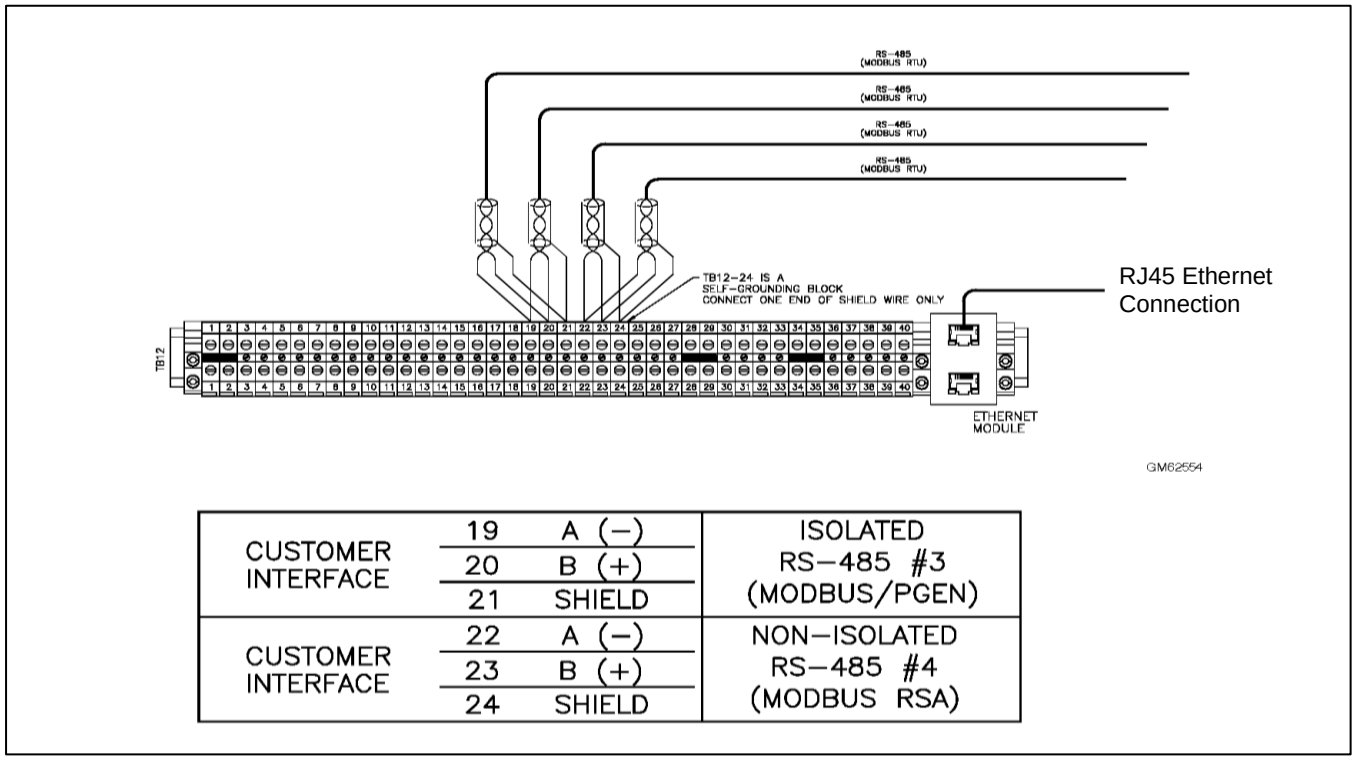

Figure 7 Connections, John Deere Models

1.4 Controller Setup

Configure the controller's communication parameters using the controller menus or Kohler® SiteTech™ 5 software and a personal computer connected to the controller's USB port.

On the APM603 controller, navigate to Setup>Communication. Check the settings for Modbus RTU or TCP and adjust, if necessary. Operator or Technician level access is required for changing the settings. The Operator password is 9879. The Technician password is provided to Kohler trained and authorized distributors and dealers.

In SiteTech 5, go to the RS485 Ports group.

Procedure to View and Change Communication Settings:

Log on to the controller using the Operator or Technician password.

1. In the navigation panel on the left side, touch Setup or the settings symbol.
2. Touch Communication or the serial connector symbol.
3. Touch the arrows on the right to scroll through the communication settings.

The numbers below correspond to the numbered steps in the Procedure to View and Change Communication Settings.

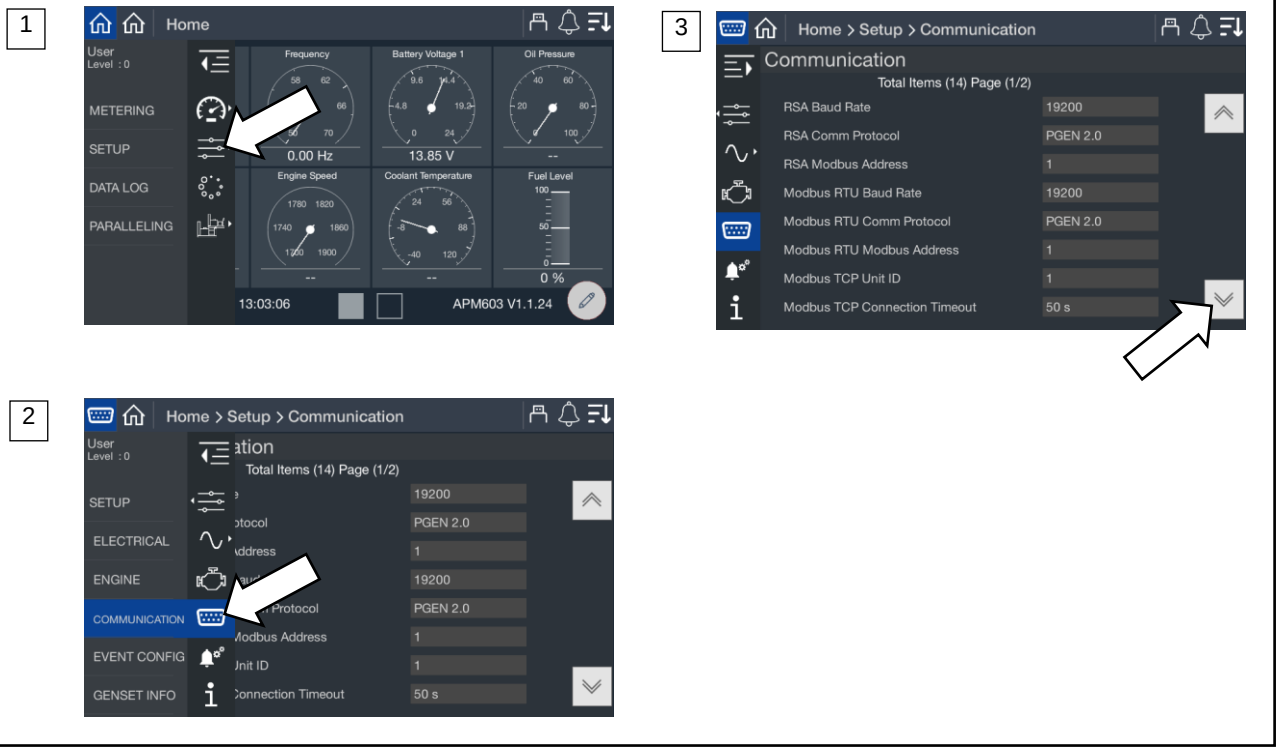

Figure 8 Setup, Communication, Modbus

The following Modbus interfaces are available:

Connection	Description	Customer Connect Terminals
RS-485 isolated	Dedicated connection for paralleling (PGEN)	TB12-8, 9, 10
RS-485 isolated	For connection to Modbus devices	TB12-19, 20, 21
RS-485 non-isolated	For connection to the RSA III remote serial annunciator	TB12-22, 23, 24
RJ45 Ethernet connection	For Modbus TCP, SNMP, and BACnet	Ethernet module

Communication Protocol

The communication protocol for each port is factory-set and not adjustable. Operator-level access is required to change the other communication settings. Contact a Kohler authorized distributor or dealer for assistance.

Baud Rates

The following baud rates can be selected. All devices in the Modbus network must use the same baud rate.

- None
- 9600 bps
- 19200 bps
- 38400 bps
- 57600 bps
- 115200 bps

Modbus Address

Each generator set controller in a system must have a unique Modbus address between 1 and 247. Use 1 for a single connection. Do not use zero (0).

Modbus TCP Unit ID

A unit ID is required for Modbus over TCP communication (Ethernet). The unit ID for TCP communication is analogous to the Modbus address for serial communication.

Parameter	Access Level	Default Setting	Range
RSA Baud Rate	Operator	19200	None, 9600, 19200, 38400, 57600, or 115200
RSA Comm Protocol	Factory set	Modbus	Not adjustable
RSA Modbus Address	Operator	1	1 - 247
Modbus RTU Baud Rate	Operator	19200	None, 9600, 19200, 38400, 57600, or 115200
Modbus RTU Comm Protocol	Factory set	Modbus	Not adjustable
Modbus RTU Modbus Address	Operator	1	
Modbus TCP Unit ID	Operator	1	
Modbus TCP Connection Timeout	Operator	5 seconds	
DHCP Enabled	Operator	Off	On or Off
IP Address	Operator	May vary	Obtain from the local network administrator.
Subnet Mask	Operator	255.255.255.0	Obtain from the local network administrator.
Default Gateway	Operator	May vary	Obtain from the local network administrator.
DNS Server 1	Operator	0	Obtain from the local network administrator.
DNS Server 2	Operator	0	Obtain from the local network administrator.

Figure 9 Communication Settings

1.5 Modbus Protocol Definitions

The APM603 controller uses the Modbus codes listed in this document to communicate with other Modbus devices. For Modbus applications, the Modbus master must be programmed to read the Modbus registers shown in this manual. A system designer trained in the application of Modbus protocol must write and thoroughly test the program before implementation.

This section defines terms and symbols used in the Modbus register tables.

Register. Modbus registers are 16-bit registers and are numbered consecutively. Request no more than 50 registers at one time. Registers are grouped into blocks of related data. Do not read registers past the end of the block where noted in the tables.

Access. All of the Modbus registers shown in the table are readable (R). Any Modbus register that is a controller setting is also writable (W).

Data Description. The data description column describes the information located at the address.

Data Type. The data type column indicates whether the parameter is BOOL, REAL32, or INT16.

- BOOL = Boolean, 0 or 1
- REAL32 = 32 bit floating point per IEEE 754
- INT16 = Integer, 16 characters maximum

Device ID. Register 409999 contains the device ID for the controller. The Device ID for the APM603 controller is 74.

1.6 Modbus Functions and Exception Codes

The APM603 controller supports the Modbus functions listed in Figure 10. The controller sends exception codes to the Modbus master to indicate errors. Figure 11 lists the exception codes and possible causes.

Modbus Function	Function Name	Description
01	Read Coils	Reads a single coil or multiple coils, controlled by “number of coils” in the request message. The request includes the address of the first coil to read and the number of coils. The number of coils field can range from 1 to 2008. If you try to read beyond the map (including reserved addresses, because these addresses are technically not in the map), you will get an exception response.
03	Read Holding Registers	Reads a single register or a range of registers.
06	Preset Single Register	Sets the value of a single register. Use this function to set all data occupying a single register.
16	Preset Multiple Registers	Sets the value of a sequence of registers. Use this function to set all data occupying multiple registers. The maximum number of registers is 16.

Figure 10 Supported Modbus Functions

Exception Code	Message	Possible Causes
01	Illegal Function	Violates the register access type. Attempts to write registers when the controller programming mode is not set to remote. Attempts to write too many registers using Preset Multiple Registers. The maximum number of registers is 16. Function is not supported.
02	Illegal Data Address	Attempts to read too many registers. The maximum is 50. Attempts to access a nonexistent register.
03	Illegal Data Value	Attempts to set a register to a value outside of the allowable limits. Attempts to set system parameters while the generator set is not in OFF or AUTO. Specifies an incorrect number of registers while attempting to read or write data occupying a sequence of registers. Attempts to modify digital input while the input is high. Attempts to modify analog input while the input is out of range. Attempts to modify preset input that cannot be changed. Attempts to read outside a restricted block. Attempts to define an invalid common fault. Attempts to activate an RDO that is not software-controlled. Attempts to start the engine while the timed run is active.

Figure 11 Supported Modbus Exception Codes

The controller reports the following abnormal values to express invalid, incorrect, or unsupported data in a given register.

Value (Hex)	Data Type	Unsigned Value (Decimal)	Signed Value (Decimal)	Description
0xFFC0	ANY	65472	-64	A Modbus register is not supported in the given application. Note: Not all unsupported registers will return the invalid register flag, some unsupported registers will return an exception response.
0x7FE0 — 0x7FFF	INT	32736 — 32767 Note: This return value is used when the value reported is a signed number. Any number larger than this will appear to be a very large negative number.	32736 — 32767	The register is supported, but the data in the register is unknown. This could indicate that the operating conditions render the data unreadable (such as sensors on an ECM engine when the ECM is not powered up), or indicate that the physical hardware to measure the quantity is either not present or replying with an out-of-range signal.
0xFFE0 — 0xFFFF	UINT	65504 — 65535	-32 — -1 Note: This return value is used when the value reported is an unsigned number. The number should not be interpreted as negative.	The register is supported, but the data in the register is unknown. This could indicate that the operating conditions render the data unreadable (such as sensors on an ECM engine when the ECM is not powered up), or indicate that the physical hardware to measure the quantity is either not present or replying with an out-of-range signal.
0x7FFFFFE0 — 0x7FFFFFFF	DINT	2147483616 — 2147483647	2147483616 — 2147483647	The register is supported, but the data in the register is unknown. This could indicate that the operating conditions render the data unreadable (such as sensors on an ECM engine when the ECM is not powered up), or indicate that the physical hardware to measure the quantity is either not present or replying with an out-of-range signal.
0xFFFFFFE0 — 0xFFFFFFFF	UDINT	4294967264 — 4294967295	4294967264 — 4294967295	The register is supported, but the data in the register is unknown. This could indicate that the operating conditions render the data unreadable (such as sensors on an ECM engine when the ECM is not powered up), or indicate that the physical hardware to measure the quantity is either not present or replying with an out-of-range signal.

1.7 Modbus Registers

1.7.1 Event Coils

The following table lists the input, output, and event coils, 100001 through 100314.

Modbus Address	Description	Type
100001	Excitation Over Voltage Input	BOOL
100002	Fuel Leak Switch Input	BOOL
100003	Remote Start Input	BOOL
100004	Breaker Closed Input	BOOL
100005	Breaker Tripped Input	BOOL
100006	Ground Fault Relay Input	BOOL
100007	Key Switch Auto Input	BOOL
100008	Key Switch Run Input	BOOL
100013	Local Emergency Stop Input	BOOL
100014	Remote Emergency Stop Input	BOOL
100021	Run / Fuel Output	BOOL
100022	Crank Output	BOOL
100023	Horn Output	BOOL
100024	Common Failure Output	BOOL
100025	Common Warning Output	BOOL
100026	High Coolant Temp Warning Output	BOOL
100027	Close Breaker Output	BOOL
100028	Trip Breaker Output	BOOL
100201	Over Crank Shutdown	BOOL
100202	Under Frequency Warning	BOOL
100203	Under Frequency Shutdown	BOOL
100204	Over Frequency Warning	BOOL
100205	Over Frequency Shutdown	BOOL
100206	Over Power Warning	BOOL
100207	Over Power Shutdown	BOOL
100208	Low Oil Pressure Warning	BOOL
100209	Low Oil Pressure Shutdown	BOOL
100210	Low Coolant Temperature Warning	BOOL
100211	High Coolant Temperature Warning	BOOL
100212	High Coolant Temperature Shutdown	BOOL
100213	Local Emergency Stop Shutdown	BOOL
100214	Remote Emergency Stop Shutdown	BOOL
100215	Over Speed Shutdown	BOOL
100216	Loss ECM Comms Shutdown	BOOL
100217	ECM Mismatch Shutdown	BOOL
100218	ECM Diagnostic Event	BOOL

Modbus Address	Description	Type
100219	Generator Running	BOOL
100220	Generator Stopped	BOOL
100221	Low Battery Voltage Warning	BOOL
100222	High Battery Voltage Warning	BOOL
100223	Battery Charger Fault Warning	BOOL
100224	Low Oil Pressure Warning ECM DTC	BOOL
100225	Low Oil Pressure Shutdown ECM DTC	BOOL
100226	High Coolant Temperature Warning ECM DTC	BOOL
100227	High Coolant Temperature Shutdown ECM DTC	BOOL
100228	High Oil Temperature Warning	BOOL
100229	High Oil Temperature Shutdown	BOOL
100230	Alternator Protection Shutdown L1	BOOL
100231	Alternator Protection Shutdown L2	BOOL
100232	Alternator Protection Shutdown L3	BOOL
100233	Emergency Power Source Supplying Power	BOOL
100234	Not In Auto Alarm	BOOL
100235	Load Shed Overload	BOOL
100236	Fuel Leak Alarm	BOOL
100237	Load Shed Under Frequency	BOOL
100238	Maintenance Reminder1	BOOL
100239	Maintenance Reminder2	BOOL
100240	Maintenance Reminder3	BOOL
100241	Weak Cranking Battery	BOOL
100242	Auto Button Pressed	BOOL
100243	Off Button Pressed	BOOL
100244	Run Button Pressed	BOOL
100245	Protective Relay Trip Over Voltage	BOOL
100246	Protective Relay Trip Under Voltage	BOOL
100247	Protective Relay Trip Over Current	BOOL
100248	Protective Relay Trip Over Frequency	BOOL
100249	Protective Relay Trip Under Frequency	BOOL
100250	Protective Relay Trip Reverse Power	BOOL
100251	Protective Relay Trip Reverse VAR	BOOL
100252	Protective Relay Trip Over Power	BOOL
100253	Protective Relay Shutdown Over Power	BOOL
100254	Protective Relay Shutdown Over Current	BOOL
100255	Protective Relay Shutdown Reverse VAR	BOOL
100256	Protective Relay Shutdown Reverse Power	BOOL
100257	Ground Fault Relay Warning	BOOL
100258	Under Voltage Warning L1 L2	BOOL

Modbus Address	Description	Type
100259	Under Voltage Warning L2 L3	BOOL
100260	Under Voltage Warning L3 L1	BOOL
100261	Under Voltage Warning L1 N	BOOL
100262	Under Voltage Warning L2 N	BOOL
100263	Under Voltage Warning L3 N	BOOL
100264	Under Voltage Shutdown L1 L2	BOOL
100265	Under Voltage Shutdown L2 L3	BOOL
100266	Under Voltage Shutdown L3 L1	BOOL
100267	Under Voltage Shutdown L1 N	BOOL
100268	Under Voltage Shutdown L2 N	BOOL
100269	Under Voltage Shutdown L3 N	BOOL
100270	Over Voltage Warning L1 L2	BOOL
100271	Over Voltage Warning L2 L3	BOOL
100272	Over Voltage Warning L3 L1	BOOL
100273	Over Voltage Warning L1 N	BOOL
100274	Over Voltage Warning L2 N	BOOL
100275	Over Voltage Warning L3 N	BOOL
100276	Over Voltage Shutdown L1 L2	BOOL
100277	Over Voltage Shutdown L2 L3	BOOL
100278	Over Voltage Shutdown L3 L1	BOOL
100279	Over Voltage Shutdown L1 N	BOOL
100280	Over Voltage Shutdown L2 N	BOOL
100281	Over Voltage Shutdown L3 N	BOOL
100282	Over Current L1Warning Warning	BOOL
100283	Over Current L2Warning Warning	BOOL
100284	Over Current L3Warning Warning	BOOL
100285	Over Current L1Shutdown Shutdown	BOOL
100286	Over Current L2Shutdown Shutdown	BOOL
100287	Over Current L3Shutdown Shutdown	BOOL
100288	Loss Of Signal Low Coolant Level	BOOL
100289	Excitation Over Voltage Shutdown	BOOL
100290	RSA Programmable Input 1	BOOL
100291	RSA Programmable Input 2	BOOL
100292	RSA Programmable Input 3	BOOL
100293	RSA Programmable Input 4	BOOL
100294	RSA Programmable Input 5	BOOL
100295	RSA Programmable Input 6	BOOL
100296	RSA Programmable Input 7	BOOL
100297	RSA Programmable Input 8	BOOL
100298	High Fuel Level Warning	BOOL

Modbus Address	Description	Type
100299	Low Fuel Level Warning	BOOL
100300	Critically Low Fuel Level Warning	BOOL
100301	Low Fuel Level Shutdown	BOOL
100302	Low Coolant Level Shutdown	BOOL
100303	Option Board Comm Loss Warning	BOOL
100310	Low RTC Battery Voltage	BOOL
100311	Over Power Shutdown	BOOL
100312	Over Power Warning	BOOL
100313	Battery Charger 1 Fault	BOOL
100314	Battery Charger 2 Fault	BOOL

Figure 12 Event Coils, JD Engines

1.7.2 Holding Registers

The following table lists the holding registers, 400001 through 409999. All Modbus registers shown in the table are readable. Any Modbus register that is a controller setting is also writable.

Modbus Address	Description	Type	Units
400001	Generator Voltage L1 L2	REAL32	Volts
400003	Generator Voltage L2 L3	REAL32	Volts
400005	Generator Voltage L3 L1	REAL32	Volts
400007	Generator Voltage L1 L0	REAL32	Volts
400009	Generator Voltage L2 L0	REAL32	Volts
400011	Generator Voltage L3 L0	REAL32	Volts
400013	Generator Current L1	REAL32	Amps
400015	Generator Current L2	REAL32	Amps
400017	Generator Current L3	REAL32	Amps
400021	Generator Frequency	REAL32	Hertz
400035	Bus Voltage L1 L2	REAL32	
400037	Bus Voltage L2 L3	REAL32	
400039	Bus Voltage L3 L1	REAL32	
400041	Bus Voltage L1 L0	REAL32	
400043	Bus Voltage L2 L0	REAL32	
400045	Bus Voltage L3 L0	REAL32	
400055	Bus Frequency	REAL32	
400243	Cooldown Time Limit	REAL32	Seconds
400245	Cooldown Temp Limit	REAL32	Degrees C
400247	Warmup Time Limit	REAL32	Seconds
400249	Warmup Temp Limit	REAL32	Degrees C
400251	Fault Cooldown Time Limit	REAL32	Seconds
400253	ECU Fuel Pressure	REAL32	kPA
400255	ECU Fuel Rate	REAL32	Liters per hour
400257	ECU Engine Speed	REAL32	RPM
400259	ECU Oil Temperature	REAL32	Degrees C
400261	ECU Coolant Temperature	REAL32	Degrees C
400263	ECU Intake Manifold Temperature	REAL32	Degrees C
400265	ECU Intake Manifold Pressure	REAL32	kPA
400267	ECU Runtime Hours	REAL32	Hours
400269	ECU Battery Voltage	REAL32	Volts
400643	Real Power L1	REAL32	Watts
400645	Real Power L2	REAL32	Watts
400647	Real Power L3	REAL32	Watts
400649	Reactive Power L1	REAL32	VAR

Modbus Address	Description	Type	Units
400651	Reactive Power L2	REAL32	VAR
400653	Reactive Power L3	REAL32	VAR
400655	Total Real Power	REAL32	Watts
400657	Total Reactive Power	REAL32	Watts
400659	Total Power Factor	REAL32	Watts
400661	Crank Cycle Count	REAL32	
400663	Voltage Average L To L	REAL32	
400665	Voltage Average L To N	REAL32	
400667	Current Average Single Phase	REAL32	
400669	Current Average Three phase	REAL32	
400671	Controller Hours	REAL32	
400673	Battery Voltage	REAL32	
409999	Controller ID, APM603 = 74	INT16	

Figure 13 Holding Registers, JD Engines

2.1 Description

There are two main components involved in SNMP: the agent and the manager. An agent is a program that can gather information about a piece of hardware, organize it into predefined entries, and respond to queries using the SNMP protocol. The SNMP manager is the component of this model that queries agents for information.

The APM603 controller supports SNMPv3.

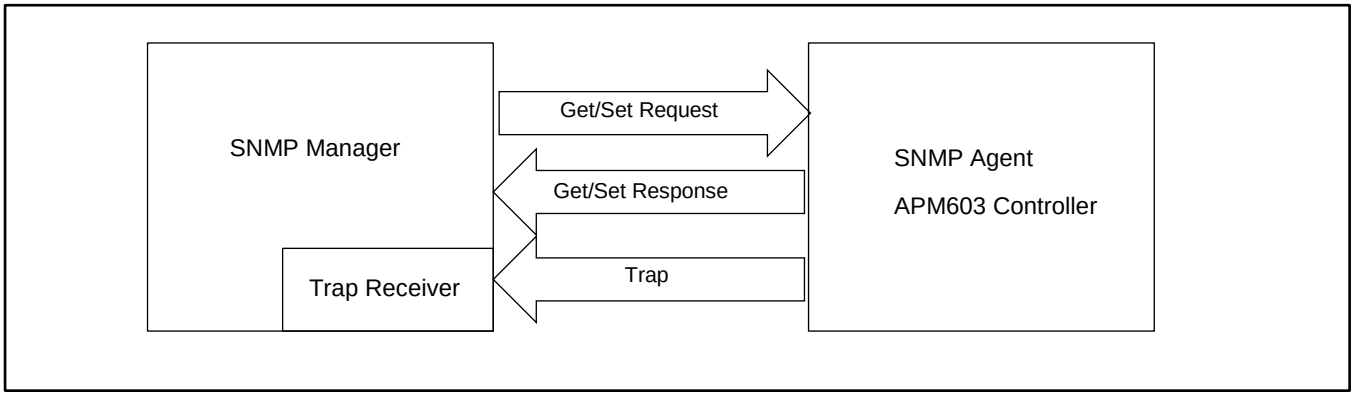

Figure 14 Top Level Diagram

Note:
Selected illustrations in this section were created using Nagios XI monitoring software. Nagios, the Nagios logo, and Nagios graphics are service marks, trademarks, or registered trademarks owned by Nagios Enterprises, LLC.

2.1.1 SNMP Basic Components and their Functionalities

SNMP consists of:

- SNMP Manager
- SNMP Agent
- Management Information Base (MIB)
- Object Identifier (OID)

SNMP Manager

A manager or management system is a separate entity that communicates with the SNMP agent implemented network devices. The manager is typically a computer that is used to run one or more network management systems.

SNMP Manager's key functions:

- Queries agents
- Gets responses from agents
- Sets variables in agents
- Acknowledges asynchronous events from agents/ Receives traps

SNMP Agent

The agent is a program that is packaged within the network element. Enabling the agent allows it to collect the management information database from the device locally and makes it available to the SNMP manager, when it is queried for. In this case the agent is Kohler Generator.

SNMP agent's key functions

- Collects management information about its local environment
- Stores and retrieves management information as defined in the MIB.
- Signals an event to the manager / Sends traps.

Management Information Base (MIB)

Every SNMP agent maintains an information database describing the managed device parameters. The SNMP manager uses this database to request specific information from the agent and further translates the information as needed for the Network Management System (NMS). This commonly shared database between the agent and the manager is called Management Information Base (MIB).

In short, MIB files are the set of questions that a SNMP manager can ask the agent. The agent collects this data locally and stores it, as defined in the MIB. The SNMP manager should be aware of the standard questions for every type of agent.

Object Identifier (OID)

An OID in SNMP is an Object Identifier, which is an address used to identify devices and their status.

OIDs uniquely identify managed objects in an MIB hierarchy.

The OID is used to refer to unique characteristics and navigate through variables on the connected device. The value of these identifiers varies from text to numbers and counters. There are two main types of Managed Objects:

- **Scalar** – A single object instance such as the device name determined by a vendor
- **Tabular** – Objects with multiple OID results for one OID

For example: the OID for a Kohler device is 1.3.6.1.4.1.51585.1

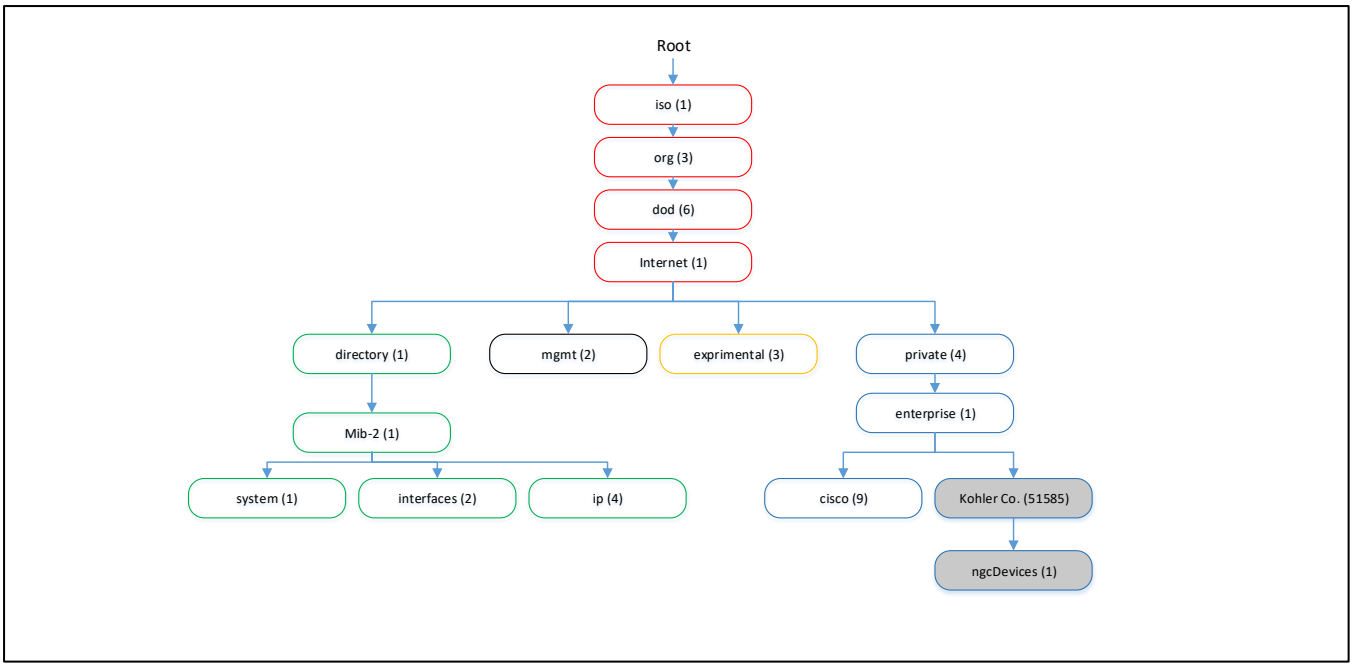

Figure 15 OID Tree

In Figure 16, the OID tree is displayed in a folder-style list:

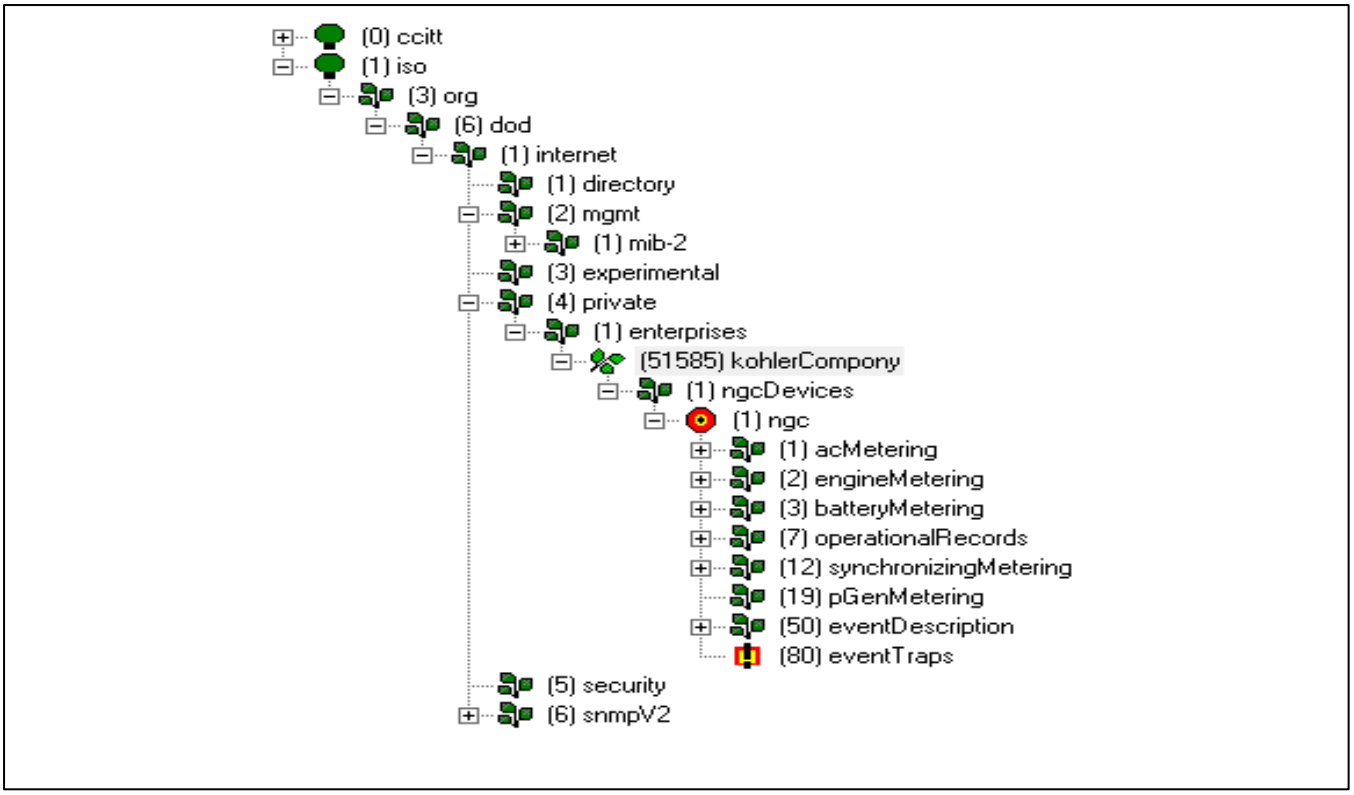

Figure 16 OID Tree in Folder Style

2.1.2 Commands/Messages

The relationship between the SNMP manager and the SNMP agent is based on messages and commands. These messages come in a range of different forms. Some of the messages exchanged by the two components are listed below:

GET – Sent when the SNMP manager is attempting to take information from the MIB to find out the value of a variable.

RESPONSE – The agent sends a RESPONSE to the SNMP manager when replying to a GET request. This provides the SNMP manager with the variables that were requested originally.

GETNEXT – The SNMP manager sends this message to the agent to get information from the next OID within the MIB tree.

GETBULK(WALK) – The SNMP agent uses the GETBULK message to pull tables of data by using lots of different GETNEXT commands.

SET – SET is a message sent by the SNMP manager to the agent to change configurations and issue commands.

TRAP – An alert sent by the SNMP agent to notify the SNMP Manager when an event happens within the device.

2.2 Setup

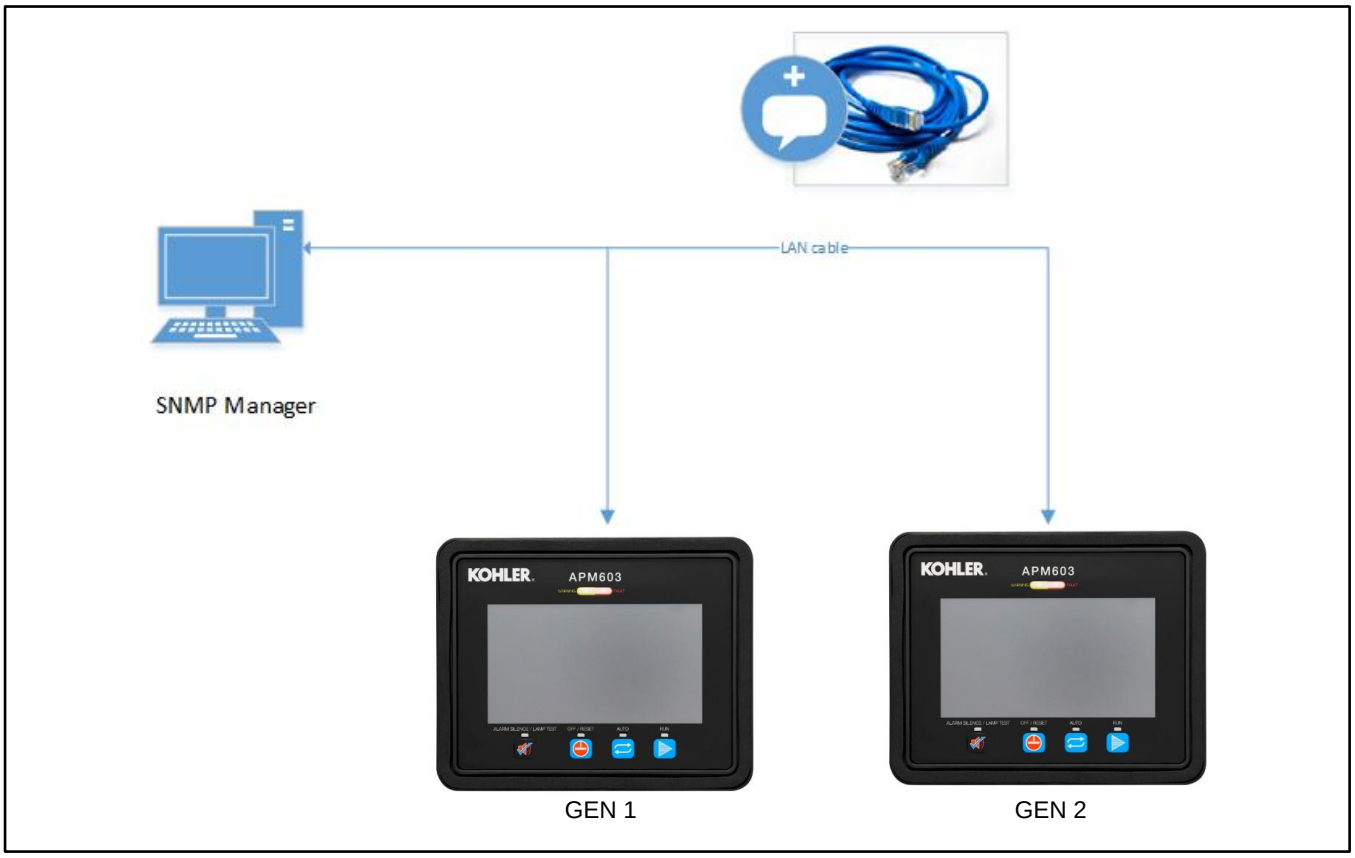

Figure 17 Hardware setup

Use a standard RJ45 connector to connect the APM603 to the network. Connect the Ethernet cable to the RJ45 port on the Ethernet module. See Figure 18.

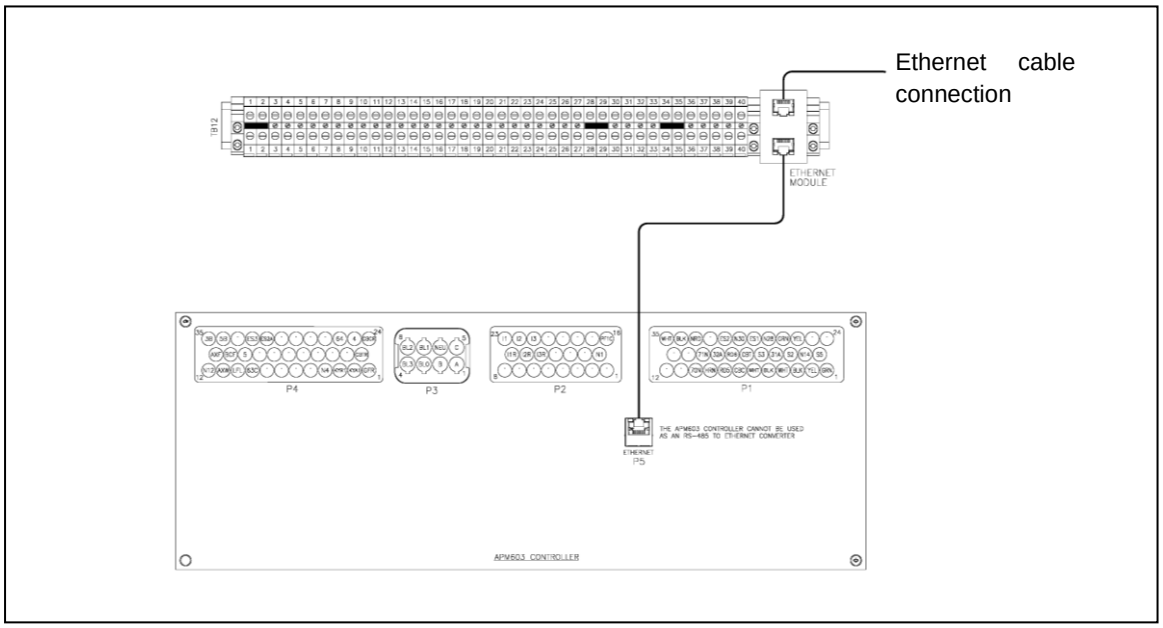

Figure 18 Ethernet Cable Connection to the APM603 Controller

Requirements

- Laptop/desktop with SNMP manager installed; this could be a free SNMP tool.
- Kohler® generator set equipped with the APM603 controller and connected to the Ethernet
- The generator set controller must be powered up.
- Load the MIB (APM603.mib) provided by Kohler in the SNMP manager application.

2.2.1 Configuration Steps

Communication Settings

In the SNMP manager, the user needs to set the destination (APM603) IP address, which is 192.168.2.7 by default. The destination port is 161. The communication settings for one of the SNMP manager tools are shown in Figure 19.

- USM User – md5des
- Context EngineID: - 00:00:12:99:7f:00:00:01:ab:cd:ef:bb

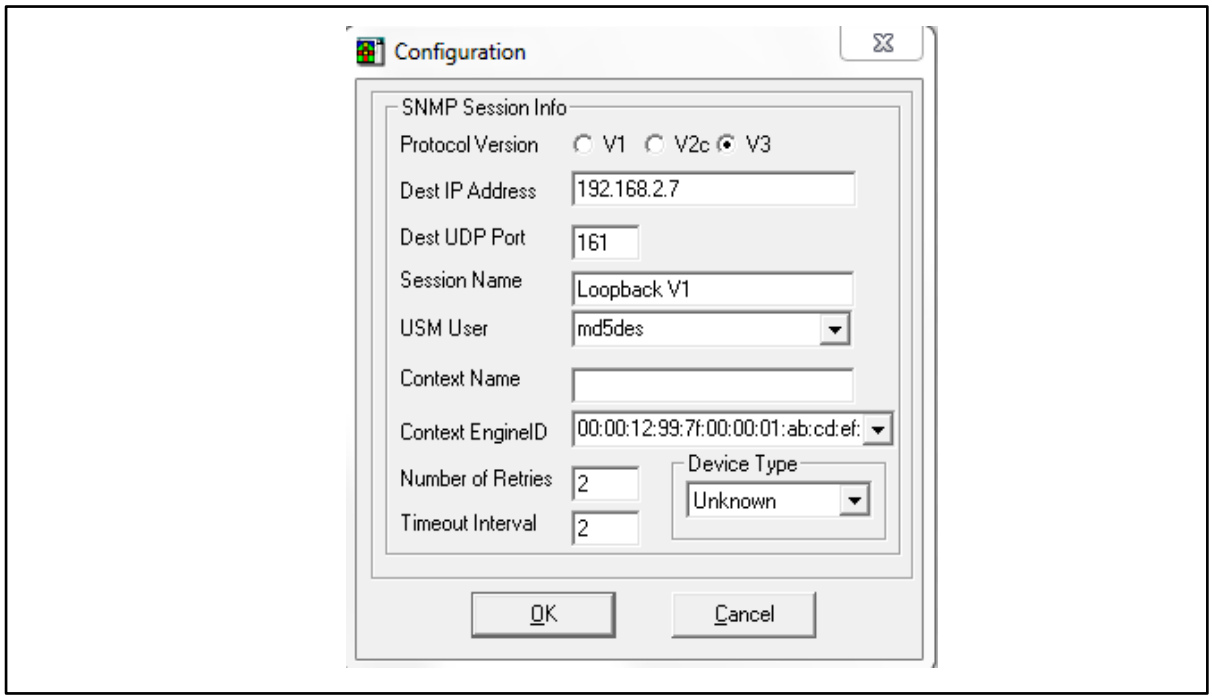

Figure 19 Communication Settings

Load the MIB

Kohler provides the Management Information Base (MIB) for the APM603 controller. The user needs to load this MIB in the SNMP manager tool. Refer to Figure 20 for the MIB loading screenshot of a sample SNMP manager.

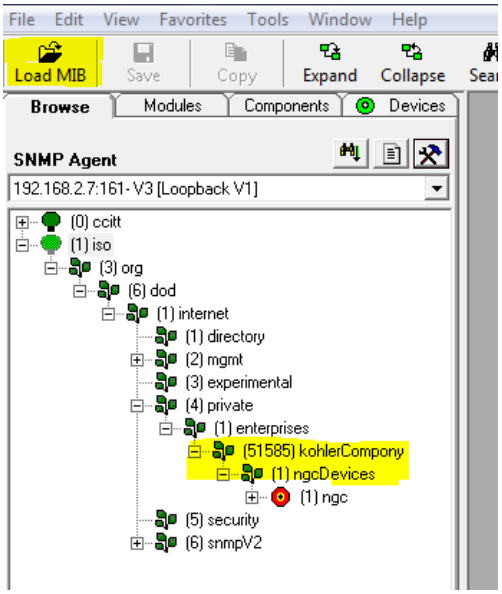

Figure 20 MIB loading

2.2.2 Reading Parameter Values

The user can read the parameters using the following commands. Write access has been restricted for the parameters. Values are read in octet string format. The user can convert the values into the required data format.

Walk Command

The user can read the values of parameters by different commands. Figure 21 shows values read by using the SNMP Walk command.

If we convert these values to float, then:

- BattVoltage1 = 12.54 v
- BattVoltage2 = 0.40 V

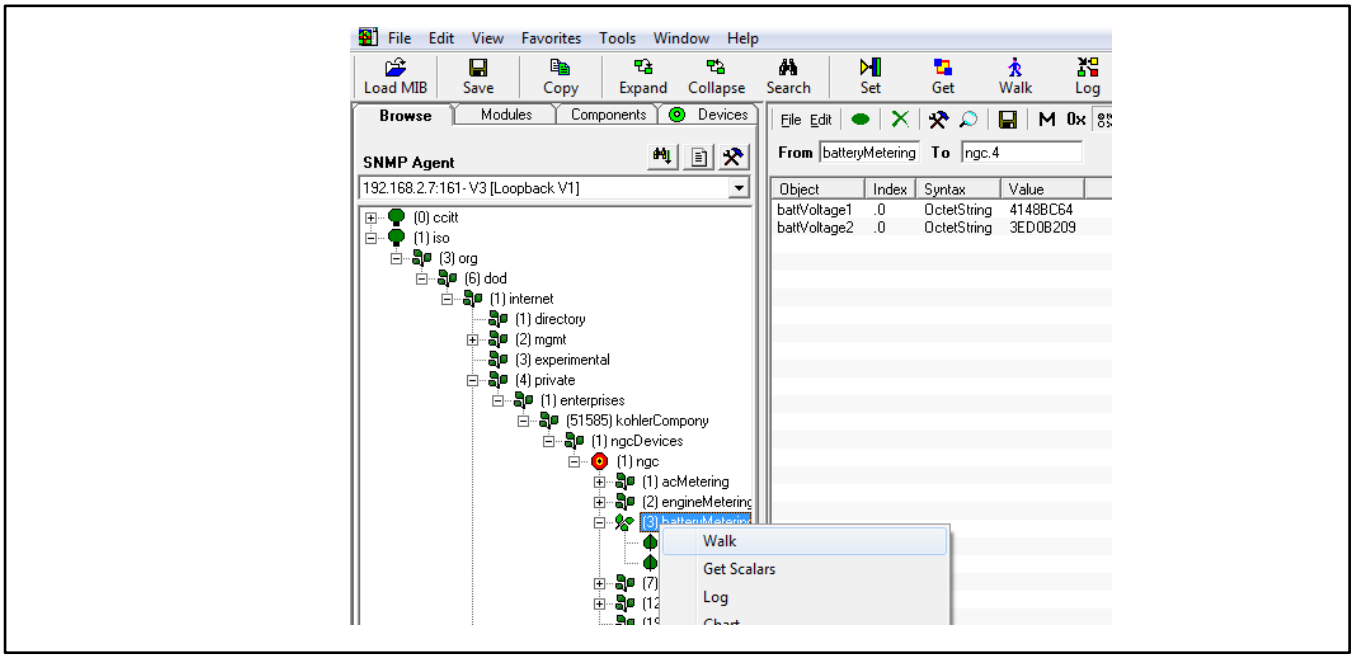

Figure 21 Walk command

User can read the specific parameter by get command as shown in following screenshot.

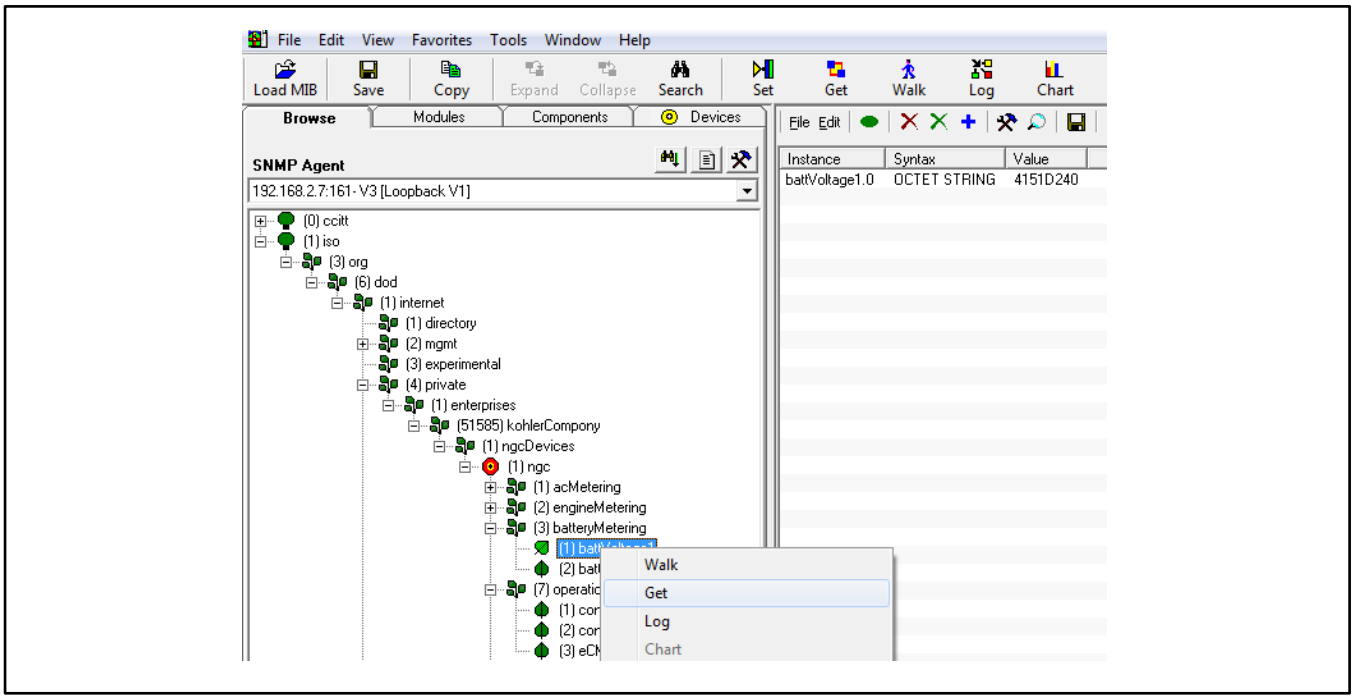

Figure 22 Get command

2.2.3 Trap Receiver

Target Address Settings

To receive traps from the APM603 controller, set the IP and port of the machine running the trap receiver application into the APM603 SNMP agent configuration file.

Load the snmpV2 standard MIB, which contains snmpModules (3) as shown below.

Note:
SNMP-TARGET-MIB contains “snmpTargetAddrName.” OBJECT-TYPE, MAX-ACCESS should be read-create for this field. Update the SNMP-TARGET-MIB.txt accordingly.

In the snmpTargetAddrTable, use the “Get Table” command to get the table content. It displays the table contents. See Figure 23.

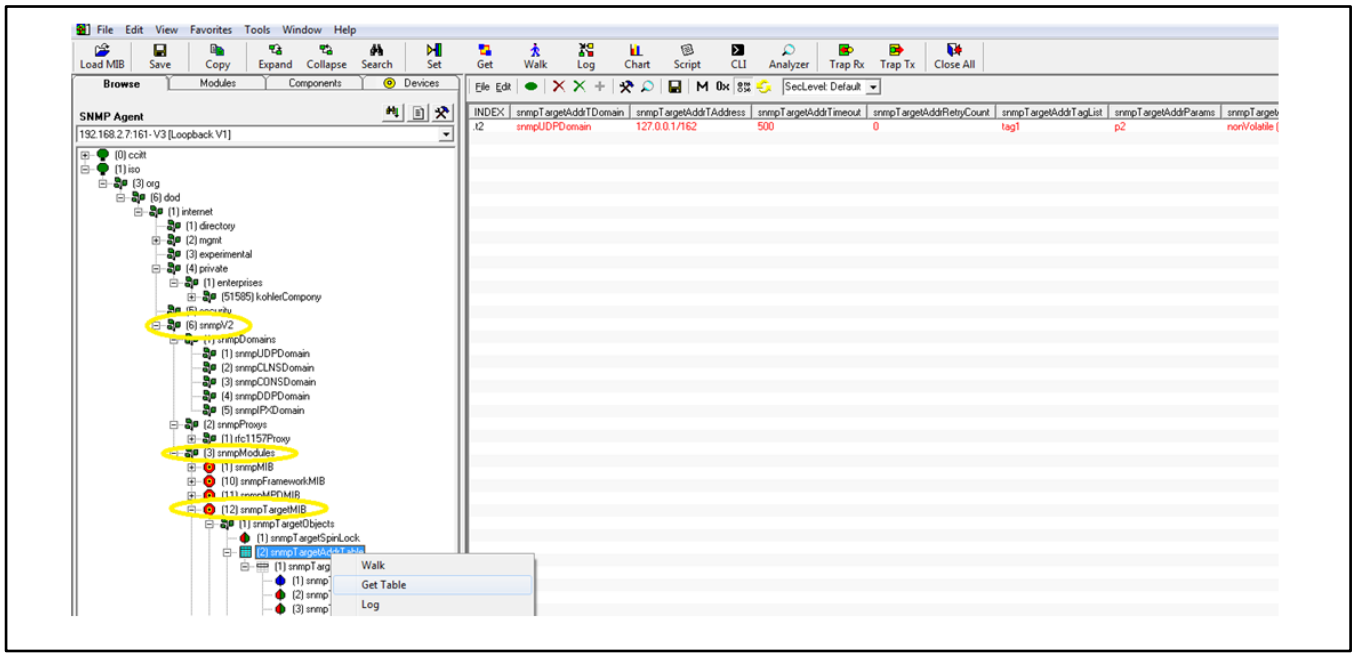

Figure 23 Get Target Address Table Information

snmpTargetAddrTable needs to be updated by creating a new row.

- Use the snmpset command, or
- In SNMP manager application create another row and provide the necessary values. See Figure 24, Figure 25, and Figure 26.

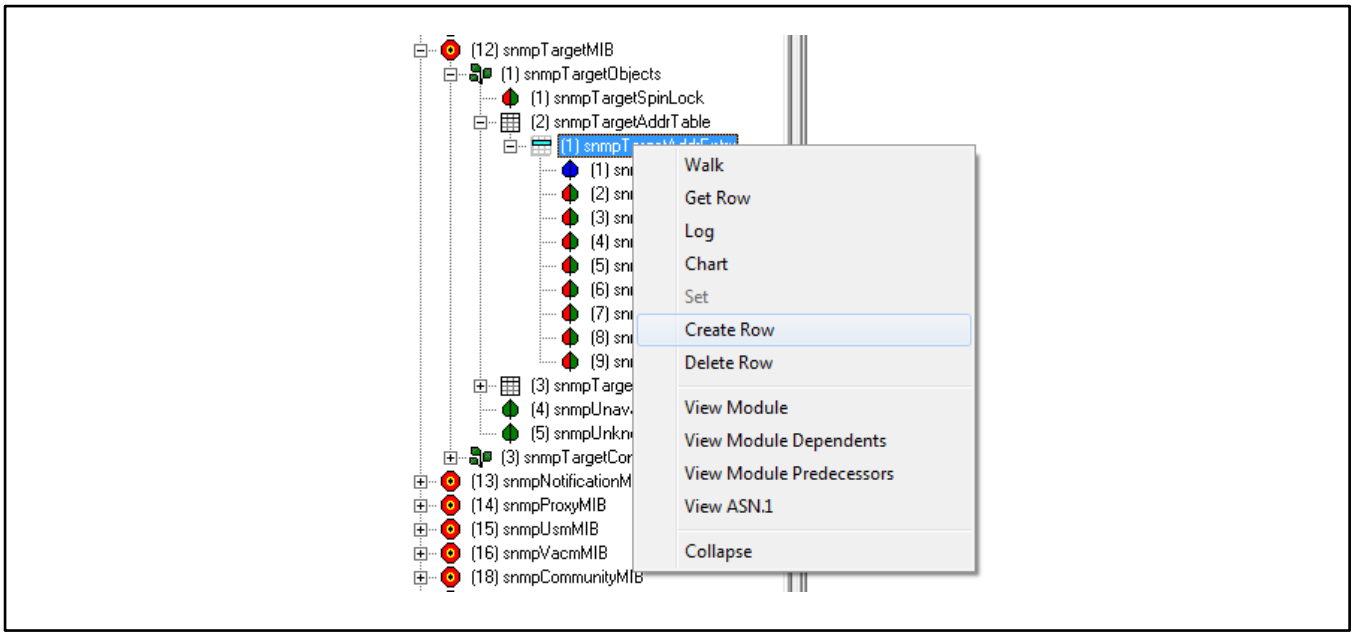

Figure 24 Create Row in Table

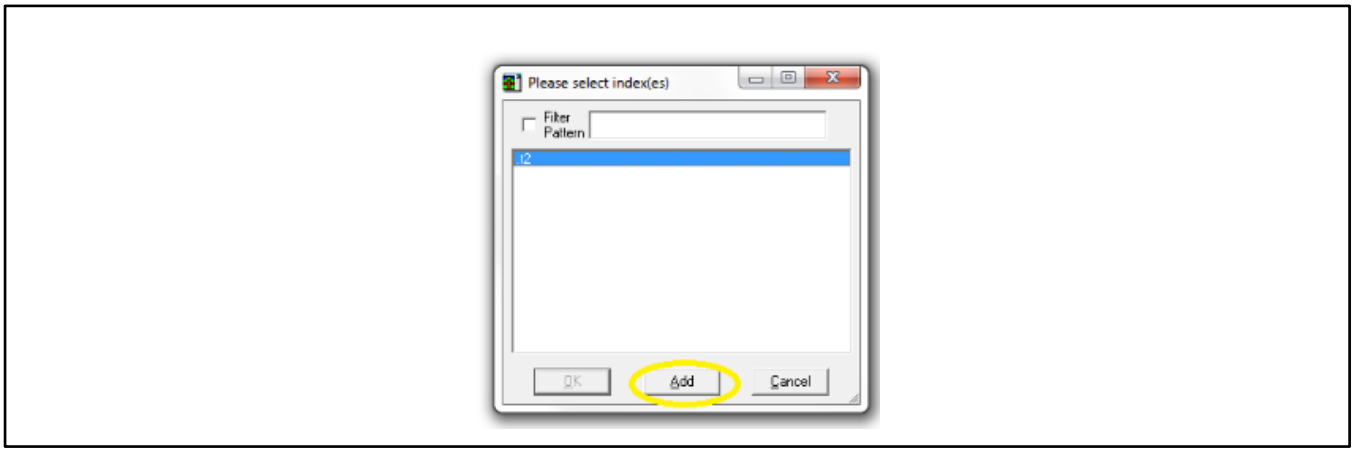

Figure 25 Add New Index

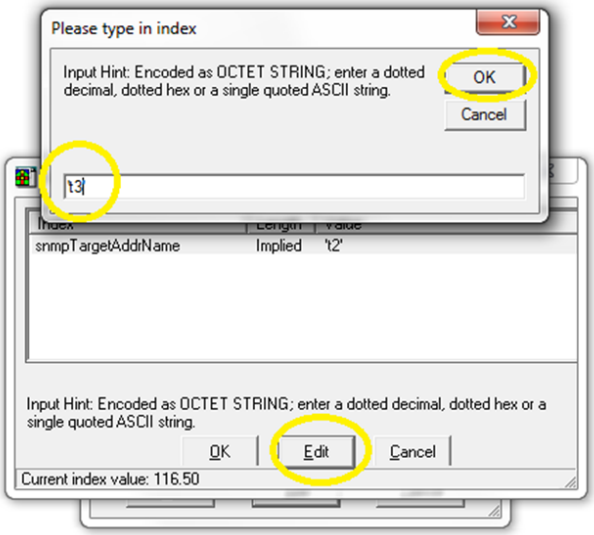

Figure 26 Target Address Name

Set all row attributes as shown in Figure 27.

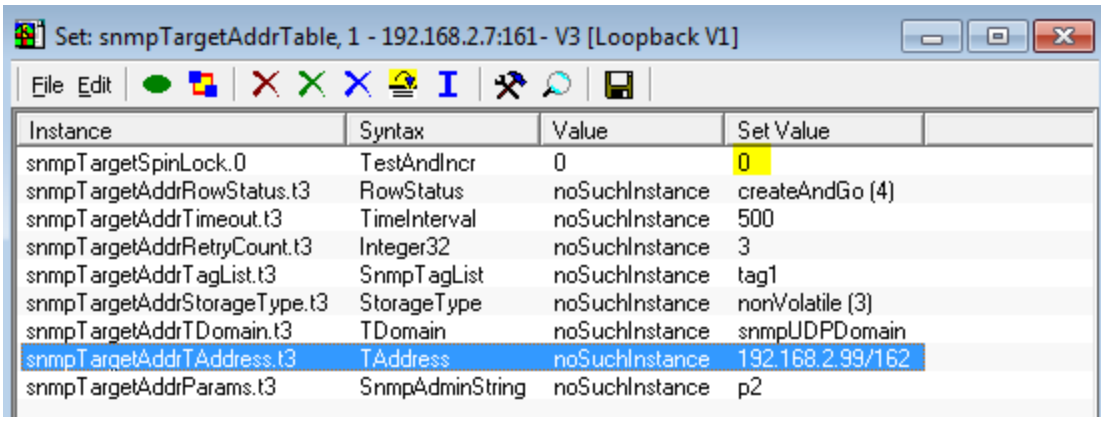

Figure 27 Before Execution of Set Command

Execute the Set command after setting values as above. The value in snmpTargetSpinLock changes 0 to 1 as shown in Figure 28.

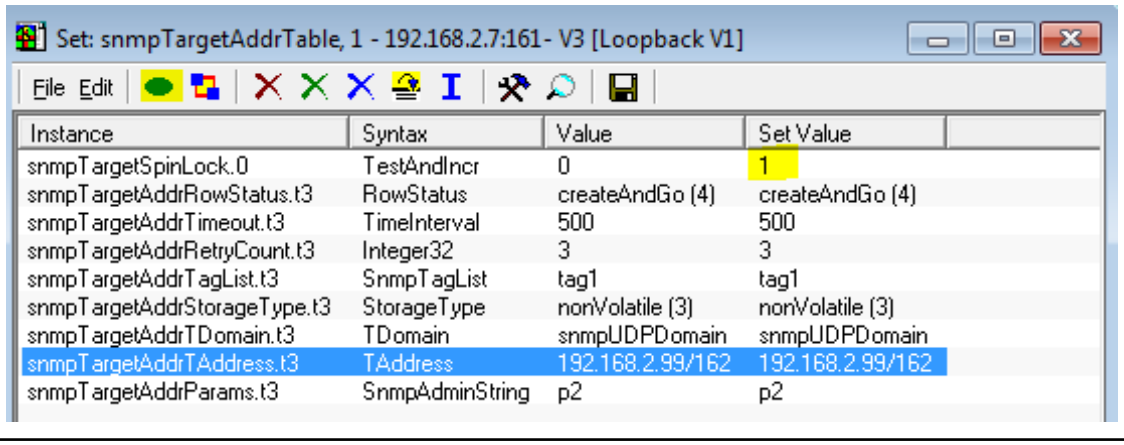

Figure 28 After Execution of Set Command

Note:
To set the trap receiver's IP and port permanently in the APM603 controller configuration, reboot/power down the APM603 controller after the above procedure.

Trap Receiver View

The user can enable the trap receiver to view the traps received from the APM603 controller. See Figure 29.

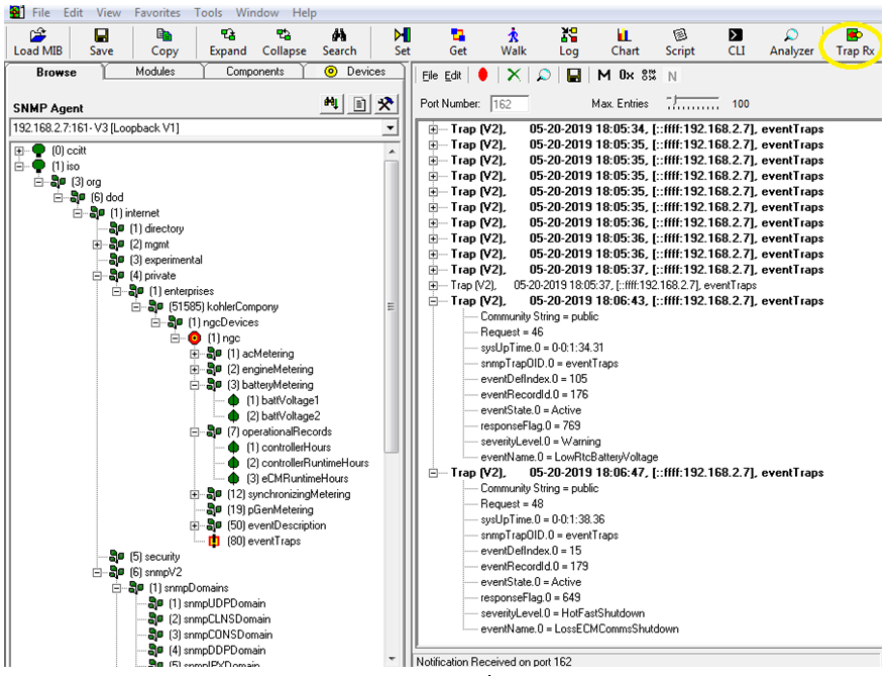

Figure 29 Received Traps

2.3 Diagnostics

Sr. No	Problem statement	Solution
1	SNMP Get or Walk command is not working	Verify the communication settings. See the Communication Settings section. Use a ping command to verify that the target is reachable.
2	SNMP-TARGET-MIB is not present under snmpV2.	Load rfc3413.mib standard MIB to view and modify the snmpTargetAddrTAddress
3	Traps are not received in trap receiver application.	Follow the process for trap receiver setting. See the Trap Receiver section.

2.4 Parameters

2.4.1 SNMP walk

Scan the APM603 generator for elements to monitor.

Figure 30 APM603 Parameter page 1

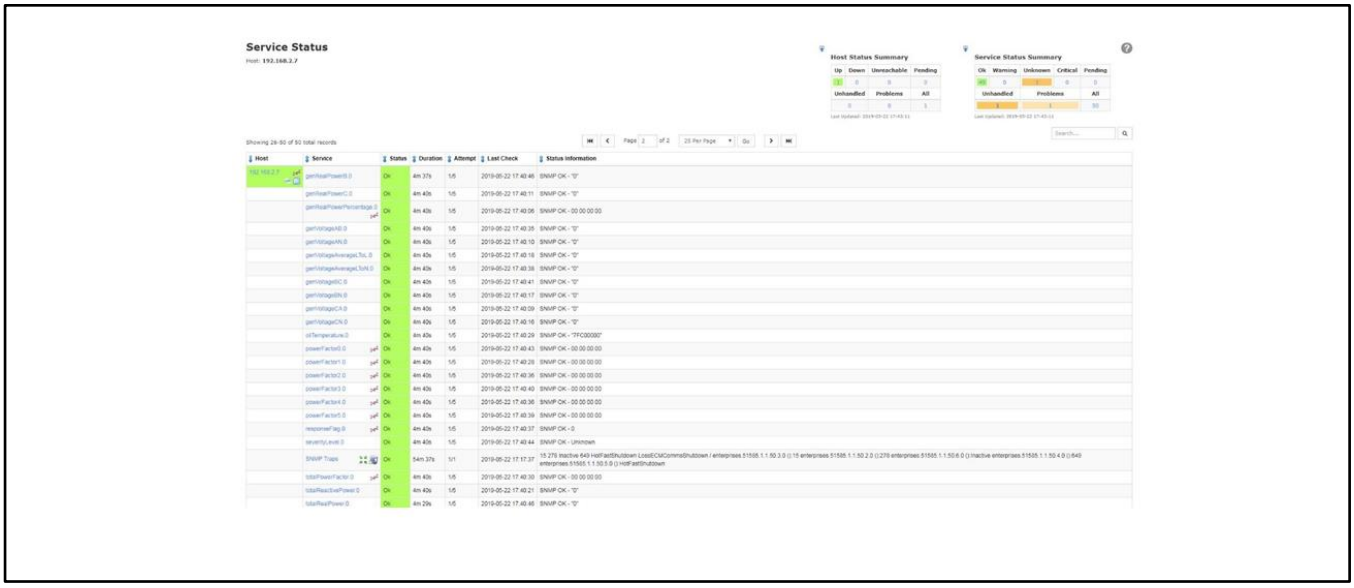

Figure 31 APM603 parameter page 2

2.4.2 Parameters and Data Types

Category	Parameter Name	SNMP	SNMP Param Name	SNMP data type	Variable Type
AC Metering	GenVoltageAB	1.3.6.1.4.1.51585.1.1.1.1	genVoltageAB	OctectString	float
AC Metering	GenVoltageBC	1.3.6.1.4.1.51585.1.1.1.2	genVoltageBC	OctectString	float
AC Metering	GenVoltageCA	1.3.6.1.4.1.51585.1.1.1.3	genVoltageCA	OctectString	float
AC Metering	GenVoltageAverageLToL	1.3.6.1.4.1.51585.1.1.1.4	genVoltageAverageLToL	OctectString	float
AC Metering	GenVoltageAN	1.3.6.1.4.1.51585.1.1.1.5	genVoltageAN	OctectString	float
AC Metering	GenVoltageBN	1.3.6.1.4.1.51585.1.1.1.6	genVoltageBN	OctectString	float
AC Metering	GenVoltageCN	1.3.6.1.4.1.51585.1.1.1.7	genVoltageCN	OctectString	float
AC Metering	GenVoltageAverageLToN	1.3.6.1.4.1.51585.1.1.1.8	genVoltageAverageLToN	OctectString	float
AC Metering	GenCurrentA	1.3.6.1.4.1.51585.1.1.1.9	genCurrentA	OctectString	float
AC Metering	GenCurrentB	1.3.6.1.4.1.51585.1.1.1.10	genCurrentB	OctectString	float
AC Metering	GenCurrentC	1.3.6.1.4.1.51585.1.1.1.11	genCurrentC	OctectString	float
AC Metering	GenCurrentN	1.3.6.1.4.1.51585.1.1.1.12	genCurrentN	OctectString	float
AC Metering	GenCurrentAverageSinglePhase	1.3.6.1.4.1.51585.1.1.1.13	genCurrentAverageSinglePhase	OctectString	float
AC Metering	GenCurrentAverageThreePhase	1.3.6.1.4.1.51585.1.1.1.14	genCurrentAverageThreePhase	OctectString	float
AC Metering	GenFrequency	1.3.6.1.4.1.51585.1.1.1.15	genFrequency	OctectString	float
AC Metering	GenRealPowerA	1.3.6.1.4.1.51585.1.1.1.16	genRealPowerA	OctectString	float
AC Metering	GenRealPowerB	1.3.6.1.4.1.51585.1.1.1.17	genRealPowerB	OctectString	float
AC Metering	GenRealPowerC	1.3.6.1.4.1.51585.1.1.1.18	genRealPowerC	OctectString	float
AC Metering	GenReactivePowerA	1.3.6.1.4.1.51585.1.1.1.19	genReactivePowerA	OctectString	float
AC Metering	GenReactivePowerB	1.3.6.1.4.1.51585.1.1.1.20	genReactivePowerB	OctectString	float
AC Metering	GenReactivePowerC	1.3.6.1.4.1.51585.1.1.1.21	genReactivePowerC	OctectString	float
AC Metering	GenTotalRealPower	1.3.6.1.4.1.51585.1.1.1.23	totalRealPower	OctectString	float
AC Metering	GenTotalReactivePower	1.3.6.1.4.1.51585.1.1.1.24	totalReactivePower	OctectString	float
AC Metering	GenTotalPowerFactor	1.3.6.1.4.1.51585.1.1.1.31	totalPowerFactor	OctectString	float
Engine Metering	GenController_CoolantTemp	1.3.6.1.4.1.51585.1.1.2.1	genCoolantTemp	OctectString	float
Engine Metering	CoolantTempearature	1.3.6.1.4.1.51585.1.1.2.2	coolantTemperature	OctectString	float
Engine Metering	EngOilPressure	1.3.6.1.4.1.51585.1.1.2.3	engOilPressure	OctectString	float
Engine Metering	OilTemperature	1.3.6.1.4.1.51585.1.1.2.4	oilTemperature	OctectString	float
Battery Metering	Analoglo_BattVoltage1	1.3.6.1.4.1.51585.1.1.3.1	battVoltage1	OctectString	float
Battery Metering	Analoglo_BattVoltage2	1.3.6.1.4.1.51585.1.1.3.2	battVoltage2	OctectString	float
Operational Records	ControllerHours	1.3.6.1.4.1.51585.1.1.7.1	controllerHours	integer32	float
Operational Records	ControllerRuntimeHours	1.3.6.1.4.1.51585.1.1.7.2	controllerRuntimeHours	integer32	Int
Operational Records	ECM_RuntimeHours	1.3.6.1.4.1.51585.1.1.7.3	eCMRuntimeHours	integer32	float
Synchronizing Metering	OpRecords_BreakerStatus	1.3.6.1.4.1.51585.1.1.12.1	breakerStatus	DisplayString	bool

Figure 32 Parameter Table with OID

3.1 BACnet general info

BACnet stands for ‘Building Automation and Control Networks’. It is the common name for the communication standard ISO 16484-5 which defines the methods and the protocol for cooperating building automation devices to communicate. Devices can be designed to operate using BACnet communication protocol as well as utilizing BACnet protocol to communicate between systems. BACnet is an internationally accepted protocol for building automation (e.g. lightning control, air conditioning and heating automation) and control over a communications network. BACnet provides a method by which computer-based control equipment from different manufacturers can work together, or 'interoperate'. For this to be achieved, components must be able to exchange and understand BACnet data messages.

The APM603 controller is equipped with BACnet support as standard.

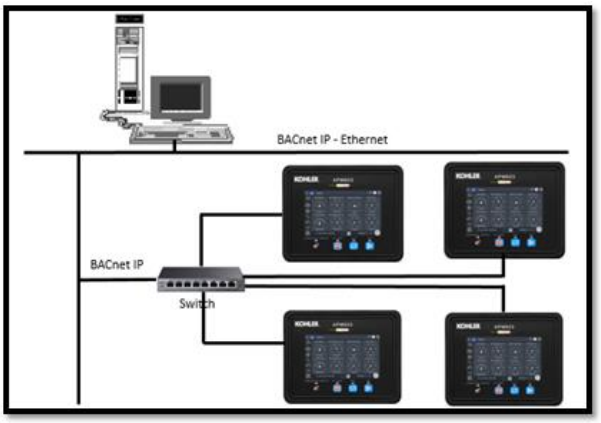

Figure 33 APM603 Connected in a BACnet Network

3.2 BACnet IP Parameter Descriptions

3.2.1 Ethernet Common Settings

Selectable alternatives are DHCP (Dynamic Host Configuration Protocol) and Fixed. DHCP protocol gives IP addresses to new devices connecting to local network. This address is valid for a certain period. A fixed IP address is specified manually, and it does not change.

IP ADDRESS

An IP address is a series of numbers (like above) specific to the device connected to the Internet.

SUBNET MASK

The network mask marks all the bits of an IP address for the identification of the network and the subnetwork.

DEFAULT GATEWAY

Gateway address is the IP address of a network point that acts as an entrance to another network.

3.2.2 BACnet IP settings

INSTANCE NUMBER

The Device Object's Instance number must be unique across the entire BACnet internetwork because it is used to uniquely identify the BACnet devices. It may be used to conveniently identify the BACnet device from other devices during installation.

In the APM603, last two octets are used as an Instance Number/Device ID.

For example, If MAC address is 60:64:05:64:CB:C1 then BACnet service will initialize with device id/ Instance number 0xcbc1(52161)

3.3 Connection

Use a standard RJ45 connector to connect the APM603 to the network. Connect the Ethernet cable to the RJ45 port on the Ethernet module. See Figure 34.

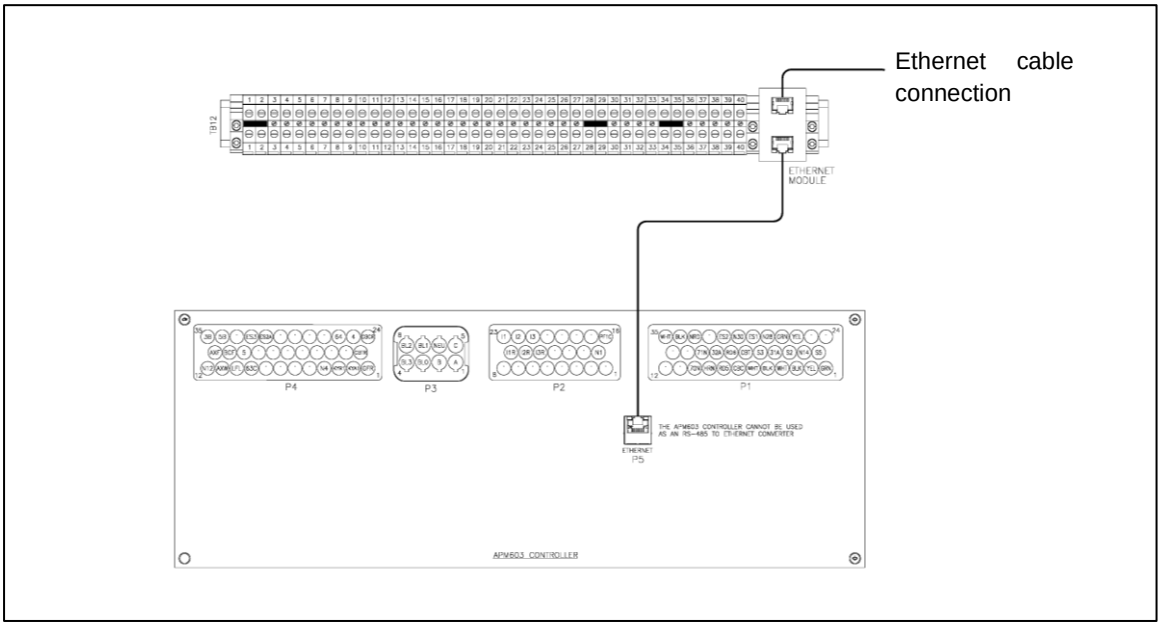

Figure 34 Ethernet Cable Connection to the APM603 Controller

3.4 Start-up

3.4.1 Initializing the APM603 BACnet

1. Default static settings for IP are:

   IP Address: 192.168.2.7

   Subnet Mask: 255.255.255.0

   Gateway: 192.168.2.1

2. If DHCP is Enabled, DHCP protocol gives IP addresses to new devices connecting to local network. If DHCP is not enabled, the IP addresses will not change.

3. The settings can be verified on the APM603 UI screen shown in Figure 35. Go to Setup>Communication to check the settings. If the settings are different than the default settings shown here, then BACnet will initialize with those settings.

4. When the APM603 is powered up, BACnet service is started by default during the startup sequence using the default/user configured IP setting.

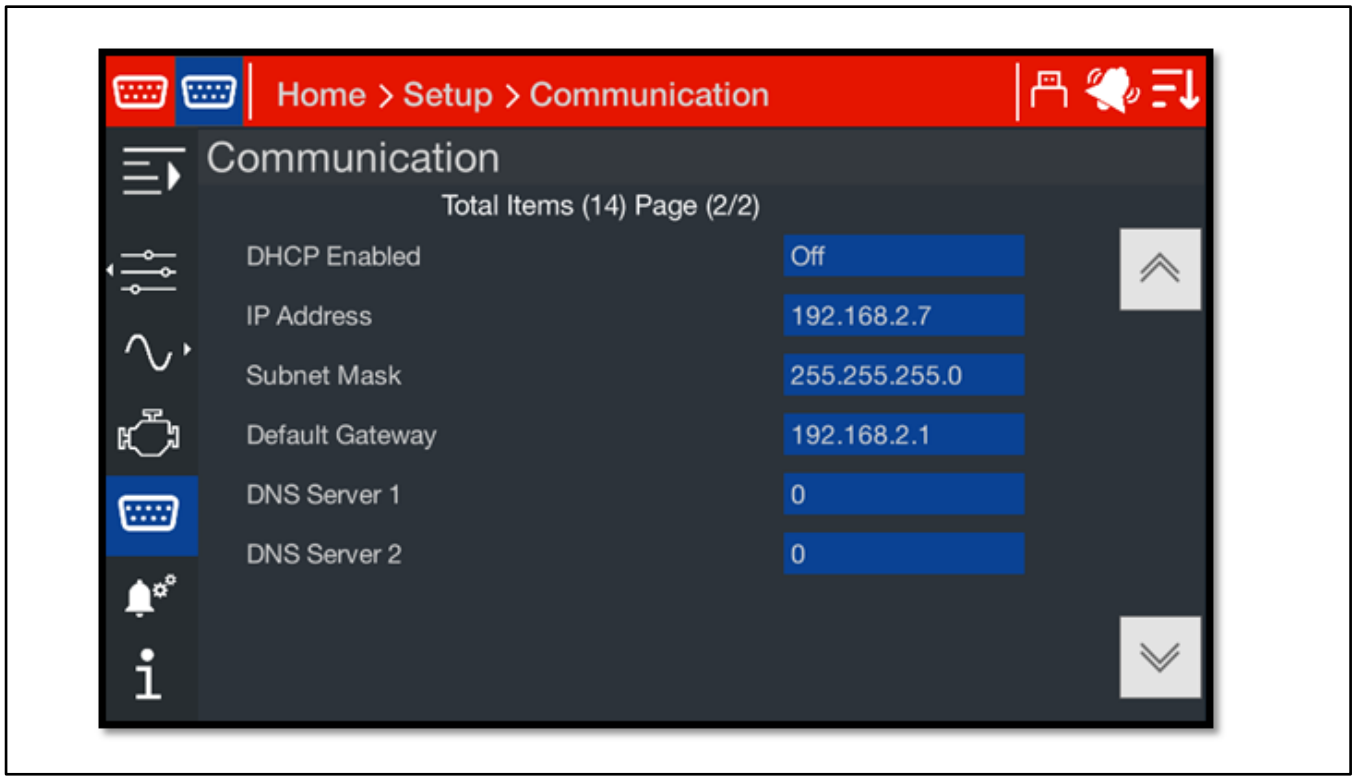

Figure 35 APM603 UI Screen for IP settings

3.5 Technical Data

3.5.1 Protocol Implementation Conformance Statement (PICS)

This statement is part of this Standard and is required for its use.

BACnet Protocol Implementation Conformance Statement	
Date:	May 29, 2019
Vendor Name:	Kohler
Product Name:	Kohler Generator
Product Model Number:	APM603
Application Software Version:	1.0
Firmware Revision:	0.0.1
BACnet Protocol Revision:	12
Product Description:	BACnet for APM603 Generator Controller
BACnet Standardized Device Profile (Annex L):	☐ **BACnet Operator Workstation (B-OWS)** ☐ **BACnet Advanced Operator Workstation (B-AWS)** ☐ **BACnet Operator Display (B-OD)** ☐ **BACnet Building Controller (B-BC)** ☐ **BACnet Advanced Application Controller (B-AAC)** ☒ **BACnet Application Specific Controller (B-ASC)** ☐ **BACnet Smart Sensor (B-SS)** ☐ **BACnet Smart Actuator (B-SA)**
List all BACnet Interoperability Building Blocks Supported (Annex K):	DS-RP-A, DS-RP-B, AE-N-A, AE-N-I-B, DM-DDB-B, DM-DOB-B
Segmentation Capability:	☐ Able to transmit segmented messages Window Size ☐ Able to receive segmented messages Window Size
Standard Object Types Supported: An object type is supported if it may be present in the device. For each standard Object Type supported provide the following data: 1) Whether objects of this type are dynamically creatable using the CreateObject service 2) Whether objects of this type are dynamically deletable using the DeleteObject service 3) List of the optional properties supported 4) List of all properties that are writable where not otherwise required by this standard 5) List of all properties that are conditionally writable where not otherwise required by this standard 6) List of proprietary properties and for each its property identifier, datatype, and meaning 7) List of any property range restrictions	See table at "Object/Property Support Matrix"
Data Link Layer Options:	☐ BACnet IP, (Annex J) ☒ BACnet IP, (Annex J), Foreign Device ☐ ISO 8802-3, Ethernet (Clause 7) ☐ ATA 878.1, 2.5 Mb. ARCNET (Clause 8) ☐ ATA 878.1, EIA-485 ARCNET (Clause 8), baud rate(s)_____ ☐ MS/TP master (Clause 9), baud rate(s): ☐ MS/TP slave (Clause 9), baud rate(s): ☐ Point-To-Point, EIA 232 (Clause 10), baud rate(s): ☐ Point-To-Point, modem, (Clause 10), baud rate(s): ☐ LonTalk, (Clause 11), medium: _____ ☐ BACnet/ZigBee (ANNEX O) ☐ Other:
Device Address Binding: Is static device binding supported? (This is currently necessary for two-way communication with MS/TP slaves and certain other devices.)	☐ Yes ☒ No
Networking Options:	☐ Router, Clause 6 - List all routing configurations, e.g., ARCNET-Ethernet, Ethernet-MS/TP, etc. ☐ Annex H, BACnet Tunneling Router over IP

BACnet Protocol Implementation Conformance Statement	
	☒ BACnet/IP Broadcast Management Device (BBMD) Does the BBMD support registrations by Foreign Devices? ☐ Yes ☐ No Does the BBMD support network address translation? ☐ Yes ☐ No
Network Security Options:	☒ Non-secure Device - is capable of operating without BACnet Network Security ☐ Secure Device - is capable of using BACnet Network Security (NS-SD BIBB) ☐ Multiple Application-Specific Keys: ☐ Supports encryption (NS-ED BIBB) ☐ Key Server (NS-KS BIBB)
Character Sets Supported: Indicating support for multiple character sets does not imply that they can all be supported simultaneously.	☐ ISO 10646 (UTF-8) ☐ IBM™/Microsoft™ DBCS ☐ ISO 8859-1 ☐ ISO 10646 (UCS-2) ☐ ISO 10646 (UCS-4) ☐ JIS X 0208

Figure 36 APM603 Device PICS

3.5.2 Object Definitions

3.5.2.1 Object/Property Support Matrix

Property	Object Type		
	Device	**Analog Input**	**Binary Input**
Object Identifier	X	X	X
Object Name	X	X	X
Object Type	X	X	X
Description	X	X	X
System Status	X		
Vendor Name	X		
Vendor Identifier	X		
Model Name	X		
Firmware Revision	X		
Appl Software Version	X		
Protocol Version	X		
Protocol Revision	X		
Services Supported	X		
Object Types Supported	X		
Object List	X		
Max APDU Length	X		
Segmentation Support	X		
APDU Timeout	X		
Number APDU Retries	X		
Max Info Frames	X		
Device Address Binding	X		
Database Revision	X		
Present Value		X	X
Status Flags		X	X
Event State		X	X
Event Enable			X
Event Time Stamps			X
Active Text			X
Inactive Text			X
Alarm Value			X
Acked Transitions			X
Time Delay			X
Notification Class			X
Notify Type			X
Out-of-Service		X	X
Units		X	
Polarity			X

Figure 37 APM603 Object/Property Support Matrix

3.5.2.2 Binary Input Object Instance Summary

The following table summarizes the Binary Input Objects supported:

Instance ID	Object Name / Description	Active/ Inactive Text	Present Value Access Type
BI0	AutoButton	active/inactive	R
BI1	EStopLocal	active/inactive	R
BI2	EStopRemote	active/inactive	R
BI3	OffButton	active/inactive	R
BI4	ProgDigIn1	active/inactive	R
BI5	ProgDigIn2	active/inactive	R
BI6	ProgDigIn3	active/inactive	R
BI7	ProgDigIn4	active/inactive	R
BI8	ProgDigIn5	active/inactive	R
BI9	ProgDigIn6	active/inactive	R
BI10	ProgDigIn7	active/inactive	R
BI11	ProgDigIn8	active/inactive	R
BI12	RunButton	active/inactive	R
BI13	AlarmSilenceLed	active/inactive	R
BI14	AutoLed	active/inactive	R
BI15	FaultLed	active/inactive	R
BI16	LcdEnabled	active/inactive	R
BI17	Rdo1	active/inactive	R
BI18	Rdo2	active/inactive	R
BI19	Rdo3	active/inactive	R
BI20	Rdo4	active/inactive	R
BI21	Rdo5	active/inactive	R
BI22	Rdo6	active/inactive	R
BI23	Rdo7	active/inactive	R
BI24	Rdo8	active/inactive	R
BI25	RunLed	active/inactive	R
BI26	WarnLed	active/inactive	R
BI27	LoadMgmtShedPriority0	active/inactive	R
BI28	LoadMgmtShedPriority1	active/inactive	R
BI29	LoadMgmtShedPriority2	active/inactive	R
BI30	LoadMgmtShedPriority3	active/inactive	R
BI31	LoadMgmtShedPriority4	active/inactive	R
BI32	LoadMgmtShedPriority5	active/inactive	R
BI33	LoadMgmtShedPriority6	active/inactive	R
BI34	LoadMgmtShedPriority7	active/inactive	R
BI35	LoadMgmtShedPriority8	active/inactive	R
BI36	LoadMgmtShedPriority9	active/inactive	R
BI37	LoadMgmtShedPriority10	active/inactive	R
BI38	LoadMgmtShedPriority11	active/inactive	R
BI39	LoadMgmtShedPriority12	active/inactive	R
BI40	LoadMgmtShedPriority13	active/inactive	R
BI41	LoadMgmtShedPriority14	active/inactive	R
BI42	LoadMgmtShedPriority15	active/inactive	R
BI43	LoadMgmtGOLAddTokWTimerActive	active/inactive	R
BI44	LoadMgmtGOLAddTimerActive	active/inactive	R
BI45	LoadMgmtTimeBasedLoadAddTimerActive	active/inactive	R
BI46	LoadMgmtUnderFrequencyShedInhibited	active/inactive	R
BI47	LoadMgmtResetRequired	active/inactive	R
BI48	ParallelFrequencyMatched	active/inactive	R
BI49	ParallelPhaseMatched	active/inactive	R
BI50	ParallelVoltageMatched	active/inactive	R
BI51	OverCrankShutdown	active/inactive	R
BI52	UnderFrequencyWarning	active/inactive	R
BI53	UnderFrequencyShutdown	active/inactive	R
BI54	OverFrequencyWarning	active/inactive	R
BI55	OverFrequencyShutdown	active/inactive	R
BI56	OverPowerWarning	active/inactive	R
BI57	OverPowerShutdown	active/inactive	R
BI58	LowOilPressureWarning	active/inactive	R
BI59	LowOilPressureShutdown	active/inactive	R
BI60	LowCoolantTemperatureWarning	active/inactive	R
BI61	HighCoolantTemperatureWarning	active/inactive	R
BI62	HighCoolantTemperatureShutdown	active/inactive	R
BI63	LocalEmergencyStopShutdown	active/inactive	R
BI64	RemoteEmergencyStopShutdown	active/inactive	R
BI65	OverSpeedShutdown	active/inactive	R
BI66	LossECMCommsShutdown	active/inactive	R

Instance ID	Object Name / Description	Active/ Inactive Text	Present Value Access Type
BI67	ECMMismatchShutdown	active/inactive	R
BI68	ECMDiagnosticEvent	active/inactive	R
BI69	GeneratorRunning	active/inactive	R
BI70	GeneratorStopped	active/inactive	R
BI71	LowBatteryVoltageWarning	active/inactive	R
BI72	HighBatteryVoltageWarning	active/inactive	R
BI73	BatteryChargerFaultWarning	active/inactive	R
BI74	LowOilPressureWarningEcmDtc	active/inactive	R
BI75	LowOilPressureShutdownEcmDtc	active/inactive	R
BI76	HighCoolantTemperatureWarningEcmDtc	active/inactive	R
BI77	HighCoolantTemperatureShutdownEcmDtc	active/inactive	R
BI78	HighOilTemperatureWarning	active/inactive	R
BI79	HighOilTemperatureShutdown	active/inactive	R
BI80	AlternatorProtectionShutdownL1	active/inactive	R
BI81	AlternatorProtectionShutdownL2	active/inactive	R
BI82	AlternatorProtectionShutdownL3	active/inactive	R
BI83	EmergencyPowerSourceSupplyingPower	active/inactive	R
BI84	NotInAutoAlarm	active/inactive	R
BI85	LoadShedOverload	active/inactive	R
BI86	FuelLeakAlarm	active/inactive	R
BI87	LoadShedUnderFrequency	active/inactive	R
BI88	MaintenanceReminder1	active/inactive	R
BI89	MaintenanceReminder2	active/inactive	R
BI90	MaintenanceReminder3	active/inactive	R
BI91	WeakCrankingBattery	active/inactive	R
BI92	AutoButtonPressed	active/inactive	R
BI93	OffButtonPressed	active/inactive	R
BI94	RunButtonPressed	active/inactive	R
BI95	ProtectiveRelayTripOverVoltage	active/inactive	R
BI96	ProtectiveRelayTripUnderVoltage	active/inactive	R
BI97	ProtectiveRelayTripOverCurrent	active/inactive	R
BI98	ProtectiveRelayTripOverFrequency	active/inactive	R
BI99	ProtectiveRelayTripUnderFrequency	active/inactive	R
BI100	ProtectiveRelayTripReversePower	active/inactive	R
BI101	ProtectiveRelayTripReverseVAR	active/inactive	R
BI102	ProtectiveRelayTripOverPower	active/inactive	R
BI103	ProtectiveRelayShutdownOverPower	active/inactive	R
BI104	ProtectiveRelayShutdownOverCurrent	active/inactive	R
BI105	ProtectiveRelayShutdownReverseVAR	active/inactive	R
BI106	ProtectiveRelayShutdownReversePower	active/inactive	R
BI107	GFCIWarning	active/inactive	R
BI108	UnderVoltageWarningL1L2	active/inactive	R
BI109	UnderVoltageWarningL2L3	active/inactive	R
BI110	UnderVoltageWarningL3L1	active/inactive	R
BI111	UnderVoltageWarningL1N	active/inactive	R
BI112	UnderVoltageWarningL2N	active/inactive	R
BI113	UnderVoltageWarningL3N	active/inactive	R
BI114	UnderVoltageShutdownL1L2	active/inactive	R
BI115	UnderVoltageShutdownL2L3	active/inactive	R
BI116	UnderVoltageShutdownL3L1	active/inactive	R
BI117	UnderVoltageShutdownL1N	active/inactive	R
BI118	UnderVoltageShutdownL2N	active/inactive	R
BI119	UnderVoltageShutdownL3N	active/inactive	R
BI120	OverVoltageWarningL1L2	active/inactive	R
BI121	OverVoltageWarningL2L3	active/inactive	R
BI122	OverVoltageWarningL3L1	active/inactive	R
BI123	OverVoltageWarningL1N	active/inactive	R
BI124	OverVoltageWarningL2N	active/inactive	R
BI125	OverVoltageWarningL3N	active/inactive	R
BI126	OverVoltageShutdownL1L2	active/inactive	R
BI127	OverVoltageShutdownL2L3	active/inactive	R
BI128	OverVoltageShutdownL3L1	active/inactive	R
BI129	OverVoltageShutdownL1N	active/inactive	R
BI130	OverVoltageShutdownL2N	active/inactive	R
BI131	OverVoltageShutdownL3N	active/inactive	R
BI132	OverCurrentL1Warning	active/inactive	R
BI133	OverCurrentL2Warning	active/inactive	R
BI134	OverCurrentL3Warning	active/inactive	R
BI135	OverCurrentL1Shutdown	active/inactive	R
BI136	OverCurrentL2Shutdown	active/inactive	R
BI137	OverCurrentL3Shutdown	active/inactive	R
BI138	LossOfSignalLowCoolantLevelVoltage	active/inactive	R

Instance ID	Object Name / Description	Active/ Inactive Text	Present Value Access Type
BI139	ExcitationOverVoltageShutdown	active/inactive	R
BI140	RSAEventProgrammableDigitalInput_1	active/inactive	R
BI141	RSAEventProgrammableDigitalInput_2	active/inactive	R
BI142	RSAEventProgrammableDigitalInput_3	active/inactive	R
BI143	RSAEventProgrammableDigitalInput_4	active/inactive	R
BI144	RSAEventProgrammableDigitalInput_5	active/inactive	R
BI145	RSAEventProgrammableDigitalInput_6	active/inactive	R
BI146	RSAEventProgrammableDigitalInput_7	active/inactive	R
BI147	RSAEventProgrammableDigitalInput_8	active/inactive	R
BI148	HighFuelLevelWarning	active/inactive	R
BI149	LowFuelLevelWarning	active/inactive	R
BI150	CriticallyLowFuelLevelWarning	active/inactive	R
BI151	LowFuelLevelShutdown	active/inactive	R
BI152	LowCoolantLevelShutdown	active/inactive	R
BI153	CanOptionBoard1Chip1CommLossWarning	active/inactive	R
BI154	CanOptionBoard1Chip2CommLossWarning	active/inactive	R
BI155	CanOptionBoard1Chip3CommLossWarning	active/inactive	R
BI156	LowRtcBatteryVoltage	active/inactive	R
BI157	GenOverPowerShutdown	active/inactive	R
BI158	GenOverPowerWarning	active/inactive	R
BI159	CanBatteryCharger1Fault	active/inactive	R
BI160	CanBatteryCharger2Fault	active/inactive	R
BI161	CanBatteryCharger3Fault	active/inactive	R
BI162	CanBatteryCharger4Fault	active/inactive	R

Figure 38 APM603 Supported Binary Input Objects

R = Read Only

3.5.2.3 Analog Input Object Instance Summary

The following table summarizes the Analog Input Objects supported:

Instance ID	Object Name / Description	Units	Present Value Access Type
AI0	GenTotalApparentPower	Volt Amperes	R
AI1	GenApparentPowerA	Volt Amperes	R
AI2	GenApparentPowerB	Volt Amperes	R
AI3	GenApparentPowerC	Volt Amperes	R
AI4	GenVoltageAverageLToL	Volts	R
AI5	GenVoltageAverageLToN	Volts	R
AI6	GenCurrentAverageSinglePhase	Amperes	R
AI7	GenCurrentAverageThreephase	Amperes	R
AI8	GenV1V2PhaseAngle		R
AI9	GenV1V3PhaseAngle		R
AI10	GenV1I1PhaseAngle		R
AI11	GenV2I2PhaseAngle		R
AI12	GenV3I3PhaseAngle		R
AI13	GenI1INPhaseAngle		R
AI14	GenFrequency	Hertz	R
AI15	GenVoltageAB	Volts	R
AI16	GenVoltageBC	Volts	R
AI17	GenCurrentB	Amperes	R
AI18	GenCurrentC	Amperes	R
AI19	GenCurrentN	Amperes	R
AI20	GenVoltageCA	Volts	R
AI21	GenVoltageAN	Volts	R
AI22	GenVoltageBN	Volts	R
AI23	GenVoltageCN	Volts	R
AI24	GenCurrentA	Amperes	R
AI25	GenReactivePowerA	Volt Amperes Reactive	R
AI26	GenReactivePowerB	Volt Amperes Reactive	R
AI27	GenReactivePowerC	Volt Amperes Reactive	R
AI28	GenRealPowerA	Watts	R
AI29	GenRealPowerB	Watts	R
AI30	GenRealPowerC	Watts	R
AI31	GenTotalRealPower	Watts	R
AI32	GenTotalReactivePower	Volt Amperes	R
AI33	GenTotalPowerFactor	Volt Amperes Reactive	R
AI34	BusVoltageAverageLToL	Volts	R
AI35	BusVoltageAverageLToN	Volts	R

Instance ID	Object Name / Description	Units	Present Value Access Type
AI36	BusV1V2PhaseAngle		R
AI37	BusV1V3PhaseAngle		R
AI38	BusFrequency	Hertz	R
AI39	BusVoltageAB	Volts	R
AI40	BusVoltageBC	Volts	R
AI41	BusVoltageCA	Volts	R
AI42	BusVoltageAN	Volts	R
AI43	BusVoltageBN	Volts	R
AI44	BusVoltageCN	Volts	R
AI45	CrankCycleCount		R
AI46	BattVoltage1	Volts	R
AI47	BattVoltage2	Volts	R
AI48	ControllerTemp	Degrees Celsius	R
AI49	DiffVoltage1	Volts	R
AI50	DiffVoltage2	Volts	R
AI51	DiffVoltage3	Volts	R
AI52	DiffVoltage4	Volts	R
AI53	DiffVoltage5	Volts	R
AI54	DiffVoltage6	Volts	R
AI55	FrxLed	Percent	R
AI56	LowCoolantLevel12vRef	Volts	R
AI57	LowCoolantLevelCurrent	Amperes	R
AI58	LowCoolantLevelVoltage	Volts	R
AI59	Ratio1	Percent	R
AI60	Ratio1_5v	Percent	R
AI61	Ratio2_5v	Percent	R
AI62	Ratio2	Percent	R
AI63	RdoCurrent1	Amperes	R
AI64	RdoCurrent2	Amperes	R
AI65	RdoCurrent3	Amperes	R
AI66	RdoCurrent4	Amperes	R
AI67	RdoCurrent5	Amperes	R
AI68	RdoCurrent6	Amperes	R
AI69	RdoCurrent7	Amperes	R
AI70	RdoCurrent8	Amperes	R
AI71	Resistive1	Percent	R
AI72	Resistive2	Percent	R
AI73	Resistive3	Percent	R
AI74	Resistive4	Percent	R
AI75	Resistive5	Percent	R
AI76	Resistive6	Percent	R
AI77	RtcBattVoltage	Volts	R
AI78	ScreenshotCount		R
AI79	LoadedRuntimeHours		R
AI80	UnloadedRuntimeHours		R
AI81	ControllerHours		R
AI82	ControllerRuntimeHours		R
AI83	ECM_RuntimeHours		R
AI84	NoOfStarts		R
AI85	NoOfCrankAttempts		R
AI86	LastCrankDuration		R
AI87	NoOfBreakerCloseAttempts		R
AI88	NoOfBreakerCloseEvents		R
AI89	LastStartDuration		R
AI90	LastStartMSec		R
AI91	LastStartSec		R
AI92	LastStartMin		R
AI93	LastStartHour		R
AI94	LastStartDay		R
AI95	LastStartMonth		R
AI96	LastStartYear		R
AI97	LastStopMSec		R
AI98	LastStopSec		R
AI99	LastStopMin		R
AI100	LastStopHour		R
AI101	LastStopDay		R
AI102	LastStopMonth		R
AI103	LastStopYear		R
AI104	TotalRealEnergy		R
AI105	TotalReactiveEnergy		R
AI106	TotalFuelUsed		R
AI107	LastStartFuelUsed		R

Instance ID	Object Name / Description	Units	Present Value Access Type
AI108	FuelConsumption		R
AI109	LastMaintRuntime1		R
AI110	LastMaintMSec1		R
AI111	LastMaintSec1		R
AI112	LastMaintMin1		R
AI113	LastMaintHour1		R
AI114	LastMaintDay1		R
AI115	LastMaintMonth1		R
AI116	LastMaintYear1		R
AI117	LastMaintTotalRealEnergy1		R
AI118	LastMaintTotalReactiveEnergy1		R
AI119	LastMaintFuelUsed1		R
AI120	DaysUntilMaint1		R
AI121	LastMaintRuntime2		R
AI122	LastMaintMSec2		R
AI123	LastMaintSec2		R
AI124	LastMaintMin2		R
AI125	LastMaintHour2		R
AI126	LastMaintDay2		R
AI127	LastMaintMonth2		R
AI128	LastMaintYear2		R
AI129	LastMaintTotalRealEnergy2		R
AI130	LastMaintTotalReactiveEnergy2		R
AI131	LastMaintFuelUsed2		R
AI132	DaysUntilMaint2		R
AI133	LastMaintRuntime3		R
AI134	LastMaintMSec3		R
AI135	LastMaintSec3		R
AI136	LastMaintMin3		R
AI137	LastMaintHour3		R
AI138	LastMaintDay3		R
AI139	LastMaintMonth3		R
AI140	LastMaintYear3		R
AI141	LastMaintTotalRealEnergy3		R
AI142	LastMaintTotalReactiveEnergy3		R
AI143	LastMaintFuelUsed3		R
AI144	DaysUntilMaint3		R
AI145	PGenMaxSupportedNodes		R
AI146	PGenStatusNumberOfSupportedNodes		R
AI147	PGenDisconnectedNodes		R
AI148	PGenConnectedNodes		R
AI149	PGenMyNodeId		R
AI150	PGenSchedulerId		R
AI151	PGenPGenMode		R
AI152	PGenPGenState		R
AI153	PGenMinSystemPhaseConnection		R
AI154	PGenMaxSystemPhaseConnection		R
AI155	PGenMinSystemVoltage		R
AI156	PGenMaxSystemVoltage		R
AI157	PGenMinSystemFrequency		R
AI158	PGenMaxSystemFrequency		R
AI159	PGenMinReactiveDroop		R
AI160	PGenMaxReactiveDroop		R
AI161	PGenDataTransmittedFlag		R
AI162	LoadMgmtkWCapacityAddAccumulator		R
AI163	LoadMgmtkWOverloadShedAccumulator		R
AI164	LoadMgmtUnderFrequencyShedAccumulator		R
AI165	LoadMgmtLoad		R
AI166	LoadMgmtLoadAfterAdding		R
AI167	LoadMgmtAvailableCapacity		R
AI168	LoadMgmtGeneratorsOnline		R
AI169	LoadMgmtGeneratorsFailed		R
AI170	LoadMgmtNextPriorityToShed		R
AI171	LoadMgmtGOLtokWCapacityTimeRemaining		R
AI172	LoadMgmtGOLAddDelayRemaining		R
AI173	LoadMgmtGOLStagingTimeRemaining		R
AI174	LoadMgmtUnderFrequencyInhbitTimeRemaining		R
AI175	LoadMgmtOnlineCapacity		R
AI176	LoadMgmtTotalBusCapacity		R
AI177	ParallelingSpeedTarget		R
AI178	ParallelingVoltageTarget		R
AI179	ParallelSpeedBias		R

Instance ID	Object Name / Description	Units	Present Value Access Type
AI180	ParallelVoltageBias		R
AI181	ParallelBusPercentageVoltage		R
AI182	ParallelGenPercentageVoltage		R
AI183	ParallelingState		R
AI184	TotalRunTimeHours		R
AI185	EngFuelRate		R
AI186	DEF1Temperature		R
AI187	EngExhaustGasTemperature		R
AI188	DEF1HeaterFMI		R
AI189	EngFuelPressure		R
AI190	DpfPassiveRegenStatus		R
AI191	DpfActiveRegenInhibtedbyPTOActive		R
AI192	DEF1Heater		R
AI193	DEF1Level2		R
AI194	RuntimeHours		R
AI195	EngIntakeManifoldNum1Pressure		R
AI196	DpfActiveRegenStatus		R
AI197	FuelTemperature		R
AI198	DpfSootLoadPercent		R
AI199	EngOilPressure		R
AI200	EngineSpeed		R
AI201	DpfAutomaticActiveRegenInitializationConfiguration		R
AI202	EngCrankcasePressure		R
AI203	DieselParticulateFilterIntakePressure		R
AI204	WaitToStartLamp		R
AI205	DpfActiveRegenForcedStatus		R
AI206	DpfExhaustGasTemperature3		R
AI207	DpfActiveRegenInhibitedStatus		R
AI208	EngIntakeManifoldNum1Temperature		R
AI209	DpfOutletGasTemperature		R
AI210	EngThrottleNum1Position		R
AI211	DpfStatus		R
AI212	SCR1OperatorinducementSeverity		R
AI213	EngCoolantLevel		R
AI214	DpfExhaustGasTemperature3FMI		R
AI215	DpfLampCommand		R
AI216	DpfConditionsNotMetforActiveRegen		R
AI217	CoolantTemperature		R
AI218	SCR1Operatorinducement		R
AI219	DpfAshLoadPercent		R
AI220	DpfHydrocarbonDoserPurgingEnable		R
AI221	EcmBatteryVoltage		R
AI222	DpfOutletGasTemperatureFMI		R
AI223	DpfHighExhaustSystemTemperature		R
AI224	DpfRengerationThreshold		R
AI225	DpfTimesincelastregen		R
AI226	DEF1LevelFMI		R
AI227	EngOilLevel		R
AI228	DEF1TemperatureFMI		R
AI229	EngIntercoolerTemperature		R
AI230	OilTemperature		R
AI231	DEF1Level		R
AI232	EngCoolantPressure		R
AI233	DpfActiveRegenInhibitedbySwitch		R

Figure 39 APM603 Supported Analog Input Objects

Appendix A. Abbreviations

A, amp	ampere	blk.	black (paint color), block (engine)	D/A	digital to analog
ABDC	after bottom dead center	blk. htr.	block heater	DAC	digital to analog converter
AC	alternating current	BMEP	brake mean effective pressure	dB	decibel
A/D	analog to digital	bps	bits per second	dB(A)	decibel (A weighted)
ADC	advanced digital control; analog to digital converter	br.	Brass	DC	direct current
adj.	adjust, adjustment	BTDC	before top dead center	DCR	direct current resistance
ADV	advertising dimensional drawing	Btu	British thermal unit	DEF	diesel exhaust fluid
AGM	absorbent glass mat	Btu/min.	British thermal units per minute	deg., °	degree
Ah	amp-hour	C	Celsius, centigrade	dept.	department
AHWT	anticipatory high water temperature	cal.	Calorie	dia.	Diameter
AISI	American Iron and Steel Institute	CAN	controller area network	DI/EO	dual inlet/end outlet
ALOP	anticipatory low oil pressure	CARB	California Air Resources Board	DIN	Deutsches Institut fur Normung e. V. (also Deutsche Industrie Normenausschuss)
alt.	alternator	CAT5	Category 5 (network cable)	DIP	dual inline package
Al	aluminum	CB	circuit breaker	DPDT	double-pole, double-throw
ANSI	American National Standards Institute (formerly American Standards Association, ASA)	CC	crank cycle	DPST	double-pole, single-throw
AO	anticipatory only	cc	cubic centimeter	DS	disconnect switch
APDC	Air Pollution Control District	CCA	cold cranking amps	DVR	digital voltage regulator
API	American Petroleum Institute	ccw.	Counterclockwise	E^2PROM, EEPROM	electrically-erasable programmable read-only memory
approx.	approximate, approximately	CEC	Canadian Electrical Code	E, emer.	emergency (power source)
APU	Auxiliary Power Unit	cert.	certificate, certification, certified	ECM	electronic control module, engine control module
AQMD	Air Quality Management District	cfh	cubic feet per hour	EDI	electronic data interchange
AR	as required, as requested	cfm	cubic feet per minute	EFR	emergency frequency relay
AS	as supplied, as stated, as suggested	CG	center of gravity	e.g.	for example (exempli gratia)
ASE	American Society of Engineers	CID	cubic inch displacement	EG	electronic governor
ASME	American Society of Mechanical Engineers	CL	centerline	EGSA	Electrical Generating Systems Association
assy.	Assembly	cm	centimeter	EIA	Electronic Industries Association
ASTM	American Society for Testing Materials	CMOS	complementary metal oxide substrate (semiconductor)	EI/EO	end inlet/end outlet
ATDC	after top dead center	com	communications (port)	EMI	electromagnetic interference
ATS	automatic transfer switch	coml	commercial	emiss.	Emission
auto.	Automatic	Coml/Rec	Commercial/Recreational	eng.	Engine
aux.	auxiliary	conn.	Connection	EPA	Environmental Protection Agency
avg.	average	cont.	continued	EPS	emergency power system
AVR	automatic voltage regulator	CPVC	chlorinated polyvinyl chloride	ER	emergency relay
AWG	American Wire Gauge	crit.	Critical	ES	engineering special, engineered special
AWM	appliance wiring material	CSA	Canadian Standards Association	ESD	electrostatic discharge
bat.	Battery	CT	current transformer	est.	estimated
BBDC	before bottom dead center	Cu	copper	E-Stop	emergency stop
BC	battery charger, battery charging	cUL	Canadian Underwriter's Laboratories	etc.	et cetera (and so forth)
BCA	battery charging alternator	cu. in.	cubic inch	exh.	exhaust
BCI	Battery Council International	cw.	Clockwise	ext.	external
BDC	before dead center	CWC	city water-cooled	F	Fahrenheit, female
BHP	brake horsepower	cyl.	Cylinder	FHM	flat head machine (screw)

fl. oz.	fluid ounce	in.	inch	Lph	liters per hour
flex.	flexible	in. H_2O	inches of water	Lpm	liters per minute
freq.	frequency	in. Hg	inches of mercury	LOP	low oil pressure
FS	full scale	in. Lb.	inch pounds	LP	liquefied petroleum
ft.	foot, feet	Inc.	incorporated	LPG	liquefied petroleum gas
ft. lb.	foot pounds (torque)	ind.	Industrial	LS	left side
ft./min.	feet per minute	int.	internal	L_{wa}	sound power level, A weighted
ftp	file transfer protocol	int./ext.	internal/external	LWL	low water level
g	gram	I/O	input/output	LWT	low water temperature
ga.	gauge (meters, wire size)	IP	internet protocol	m	meter, milli (1/1000)
gal.	gallon	ISO	International Organization for Standardization	M	mega (10^6 when used with SI units), male
gen.	generator	J	joule	m^3	cubic meter
genset	generator set	JIS	Japanese Industry Standard	m^3/hr.	cubic meters per hour
GFI	ground fault interrupter	k	kilo (1000)	m^3/min.	cubic meters per minute
GND, ⏚	ground	K	kelvin	mA	milliampere
gov.	governor	kA	kiloampere	man.	manual
gph	gallons per hour	KB	kilobyte (2^{10} bytes)	max.	maximum
gpm	gallons per minute	KBus	Kohler communication protocol	MB	megabyte (2^{20} bytes)
gr.	grade, gross	kg	kilogram	MCCB	molded-case circuit breaker
GRD	equipment ground	kg/cm^2	kilograms per square centimeter	MCM	one thousand circular mils
gr. wt.	gross weight	kgm	kilogram-meter	meggar	megohmmeter
H x W x D	height by width by depth	kg/m^3	kilograms per cubic meter	MHz	megahertz
HC	hex cap	kHz	kilohertz	mi.	mile
HCHT	high cylinder head temperature	kJ	kilojoule	mil	one one-thousandth of an inch
HD	heavy duty	km	kilometer	min.	minimum, minute
HET	high exhaust temp., high engine temp.	kOhm, kΩ	kilo-ohm	misc.	miscellaneous
hex	hexagon	kPa	kilopascal	MJ	megajoule
Hg	mercury (element)	kph	kilometers per hour	mJ	millijoule
HH	hex head	kV	kilovolt	mm	millimeter
HHC	hex head cap	kVA	kilovolt ampere	mOhm, mΩ	milliohm
HP	horsepower	kVAR	kilovolt ampere reactive	MOhm, MΩ	megohm
hr.	hour	kW	kilowatt	MOV	metal oxide varistor
HS	heat shrink	kWh	kilowatt-hour	MPa	megapascal
hsg.	Housing	kWm	kilowatt mechanical	mpg	miles per gallon
HVAC	heating, ventilation, and air conditioning	kWth	kilowatt-thermal	mph	miles per hour
HWT	high water temperature	L	liter	MS	military standard
Hz	hertz (cycles per second)	LAN	local area network	ms	millisecond
IBC	International Building Code	L x W x H	length by width by height	m/sec.	meters per second
IC	integrated circuit	lb.	pound, pounds	mtg.	mounting
ID	inside diameter, identification	lbm/ft^3	pounds mass per cubic feet	MTU	Motoren-und Turbinen-Union
IEC	International Electrotechnical Commission	LCB	line circuit breaker	MW	megawatt
IEEE	Institute of Electrical and Electronics Engineers	LCD	liquid crystal display	mW	milliwatt
IMS	improved motor starting	LED	light emitting diode	µF	microfarad

N, norm.	normal (power source)	PMG	permanent magnet generator	SCR	silicon controlled rectifier (electrical), selective catalytic reduction (exhaust emissions)
NA	not available, not applicable	pot	potentiometer, potential	s, sec.	second
nat. gas	natural gas	ppm	parts per million	SI	*Systeme international d'unites*, International System of Units
NBS	National Bureau of Standards	PROM	programmable read-only memory	SI/EO	side in/end out
NC	normally closed	psi	pounds per square inch	sil.	Silencer
NEC	National Electrical Code	psig	pounds per square inch gauge	SMTP	simple mail transfer protocol
NEMA	National Electrical Manufacturers Association	pt.	pint	SN	serial number
NiCd	nickel cadmium	PTC	positive temperature coefficient	SNMP	simple network management protocol
NFPA	National Fire Protection Association	PTO	power takeoff	SPDT	single-pole, double-throw
Nm	newton meter	PVC	polyvinyl chloride	SPST	single-pole, single-throw
NO	normally open	PVC	polyvinyl chloride	spec	specification
no., nos.	number, numbers	PWM	pulse width modulated, pulse width modulation	specs	specification(s)
NPS	National Pipe, Straight	qt.	quart, quarts	sq.	square
NPSC	National Pipe, Straight-coupling	qty.	quantity	sq. cm	square centimeter
NPT	National Standard taper pipe thread per general use	R	replacement (emergency) power source	sq. in.	square inch
NPTF	National Pipe, Taper-Fine	rad.	radiator, radius	SMS	short message service
NR	not required, normal relay	RAM	random access memory	SS	stainless steel
Ns	nanosecond	RDO	relay driver output	std.	standard
OC	overcrank	ref.	reference	stl.	Steel
OD	outside diameter	rem.	Remote	tach.	Tachometer
OEM	original equipment manufacturer	Res/Coml	Residential/Commercial	TB	terminal block
OF	overfrequency	RFI	radio frequency interference	TCP	transmission control protocol
opt.	option, optional	RH	round head	TD	time delay
OS	oversize, overspeed	RHM	round head machine (screw)	TDC	top dead center
OSHA	Occupational Safety and Health Administration	rly.	Relay	TDEC	time delay engine cooldown
OSHPD	Office of Statewide Health Planning and Development (California)	rms	root mean square	TDEN	time delay emergency to normal
OV	overvoltage	rnd.	Round	TDES	time delay engine start
oz.	ounce	RO	read only	TDNE	time delay normal to emergency
p., pp.	page, pages	ROM	read only memory	TDOE	time delay off to emergency
PC	personal computer	rot.	rotate, rotating	TDON	time delay off to normal
PCB	printed circuit board	rpm	revolutions per minute	temp.	temperature
pF	picofarad	RS	right side	term.	Terminal
PF	power factor	RTDs	resistance temperature detectors	THD	total harmonic distortion
ph., ø	phase	RTU	remote terminal unit	TIF	telephone influence factor
PHC	Phillips® head Crimptiter (screw)	RTV	room temperature vulcanization	tol.	Tolerance
PHH	Phillips® hex head (screw)	RW	read/write	turbo.	Turbocharger
PHM	pan head machine (screw)	SAE	Society of Automotive Engineers	typ.	typical (same in multiple locations)
PLC	programmable logic control	scfm	standard cubic feet per minute	UF	underfrequency

UHF	ultrahigh frequency
UIF	user interface
UL	Underwriter's Laboratories, Inc.
UNC	unified coarse thread (was NC)
UNF	unified fine thread (was NF)
univ.	universal
URL	uniform resource locator (web address)
US	undersize, underspeed
UV	ultraviolet, undervoltage
V	volt
VAC	volts alternating current
VAR	voltampere reactive
VDC	volts direct current
VFD	vacuum fluorescent display
VGA	video graphics adapter
VHF	very high frequency
W	watt
WCR	withstand and closing rating
w/	with
WO	write only
w/o	without
wt.	weight
xfmr	transformer

Appendix B. Noise and Wiring Practices

Electrical noise is an unwanted electrical signal that can cause errors in measurement, loss of control, malfunctions in microprocessor-based control systems, errors in data transfer between systems over communication links, or reductions in system performance.

Good system design and wiring practices can minimize noise levels and the effects of noise.

Noise, because of its random nature, is typically characterized by frequency distribution. Many noise sources are broad-spectrum, that is, they produce many frequencies distributed over a wide range. Broad spectrum noise is particularly troublesome because it cannot be removed easily by filtering, and because it can affect a variety of systems in unpredictable ways. One common source of broad-spectrum noise is a switch, which can produce voltage and current changes when an electrical circuit is connected and disconnected.

Coupling is the transfer of signals between separate circuits. Signals from one circuit become noise in another. The amount of coupling is cumulative and is a function of the proximity of the circuits, their orientation, exposed area, and length of run. Minimize coupling by the following:

- Isolating circuits from each other by using separate raceways or conduit
- Separating circuits from each other by locating them as far apart as possible
- Enclosing circuits with a grounded metallic shield such as an enclosure, metallic conduit, or cable shield
- Running conductor's perpendicular, rather than parallel, to each other
- Running wires loosely and randomly rather than bundling them tightly together
- Twisting a circuit's wires together in pairs

In an industrial environment, there are typically five types of circuits with different noise emission and rejection capabilities. The five types of circuits are as follows:

- **High-Power Distribution.** Circuits to high-power loads such as large electric motors and heaters can emit transient high levels of broad-spectrum noise. Loads on high-power distribution circuits are nearly immune to noise.
- **General Purpose Power Distribution.** Circuits to medium-power loads such as lighting, offices, light duty equipment, and small motors such as fans and pumps can emit transient, medium levels of broad-spectrum noise. Some electronic equipment, such as computers, emits constant levels of broad-spectrum noise in addition to transient broad-spectrum noise. Loads on general-purpose circuits, except for sensitive electronic equipment, are nearly immune to noise.
- **Control.** Control circuits include DC circuits and 120 VAC maximum AC circuits that operate at a low power level (less than 1 W). Typical circuits include circuits to switches, actuators, anddry – contact relays, including the generator engine-start circuit. Control circuits emit transient low levels of broad-spectrum noise and are fairly immune to noise.
- **Analog.** Analog circuits are low-voltage DC circuits that convey measurement information as relatively small changes in current or voltage. Typical circuits include those connected to the controller's analog inputs. Analog circuits create the lowest noise levels and are the most sensitive to noise.
- **Communication and Signaling.** Communication and signaling circuits are low-voltage circuits that convey information. Typical circuits include RS-232 and RS-485 serial communication lines, telephone lines, and computer network lines. These circuits create noise with frequencies related to the communication signaling rate. These circuits have some level of built-in noise immunity. Typical systems will detect or correct errors caused by noise below certain levels, but with a corresponding reduction in the data transfer rate.

When planning an installation, separate all of these types of circuits as much as possible to minimize the hazards of insulation failure, accidental miswiring, and noise coupling. For best results, install control circuits, analog circuits, and communication and signaling circuits separately. Combining circuit types is unavoidable in the controller's enclosure and some other areas.

Note:

It is very important to isolate high- and medium power circuits in raceways or conduit separate from the other types of circuits.

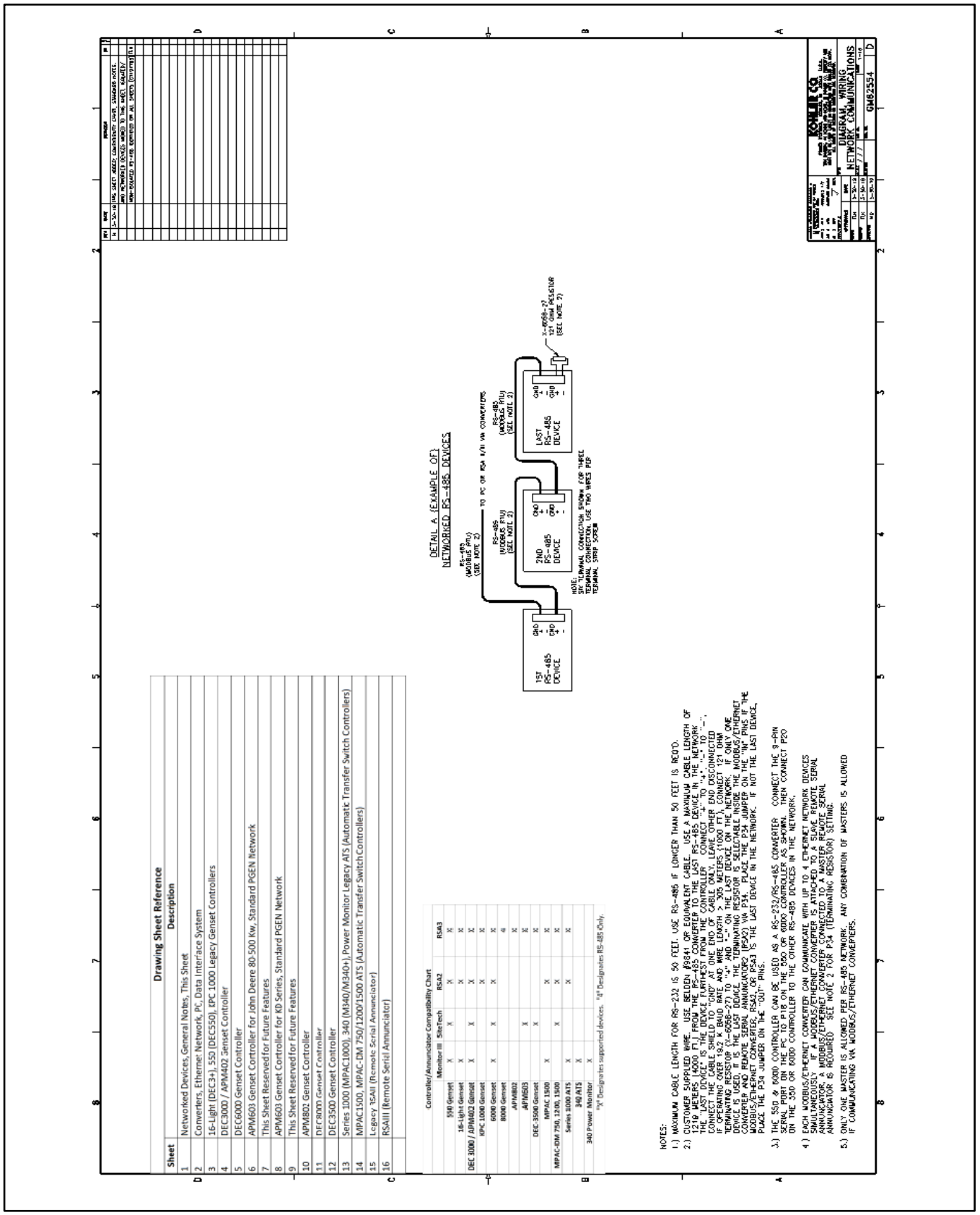

Figure 40 Wiring Diagram, Network Communications, GM62554, Sheet 1

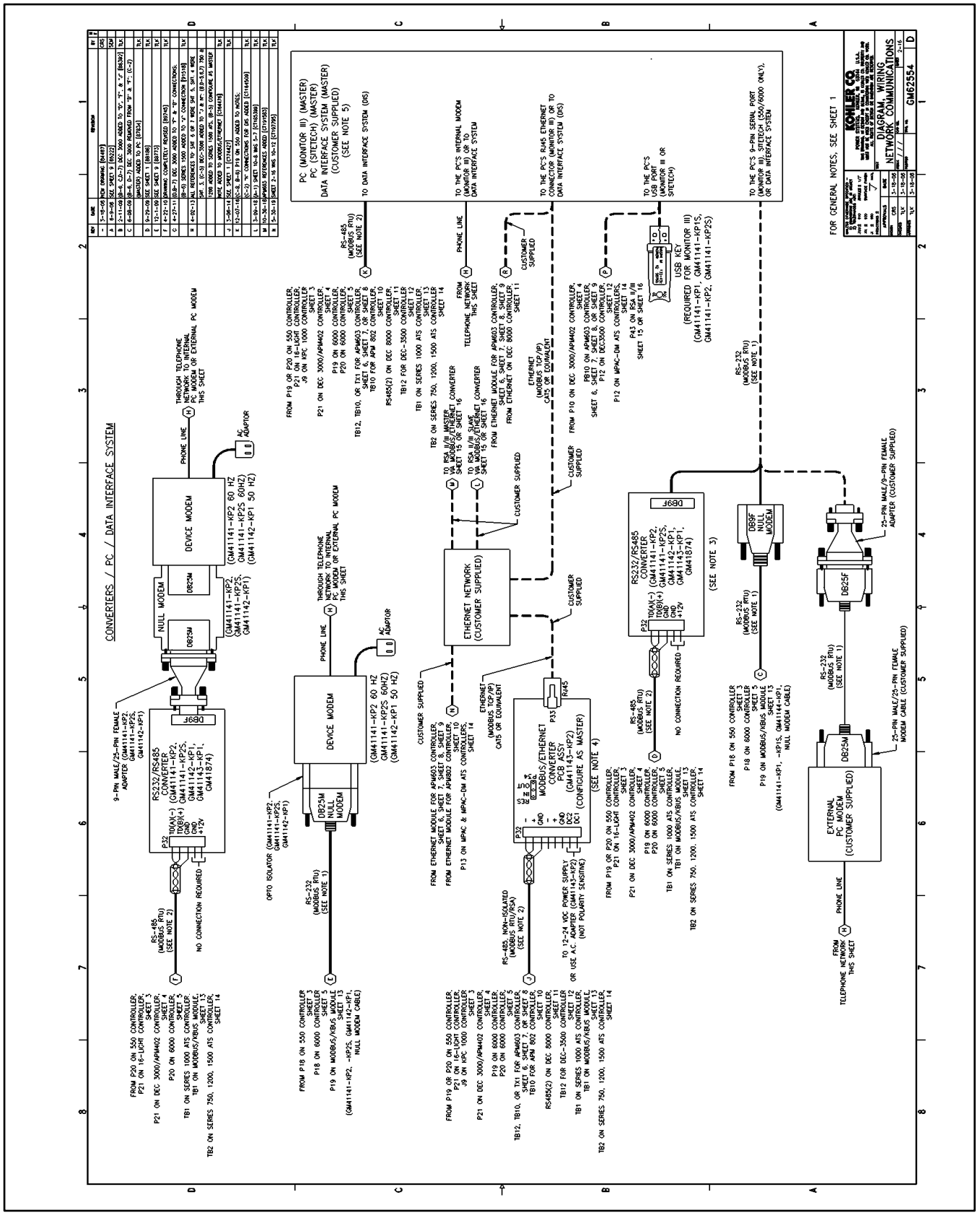

Figure 41 Wiring Diagram, Network Communications, GM62554, Sheet 2

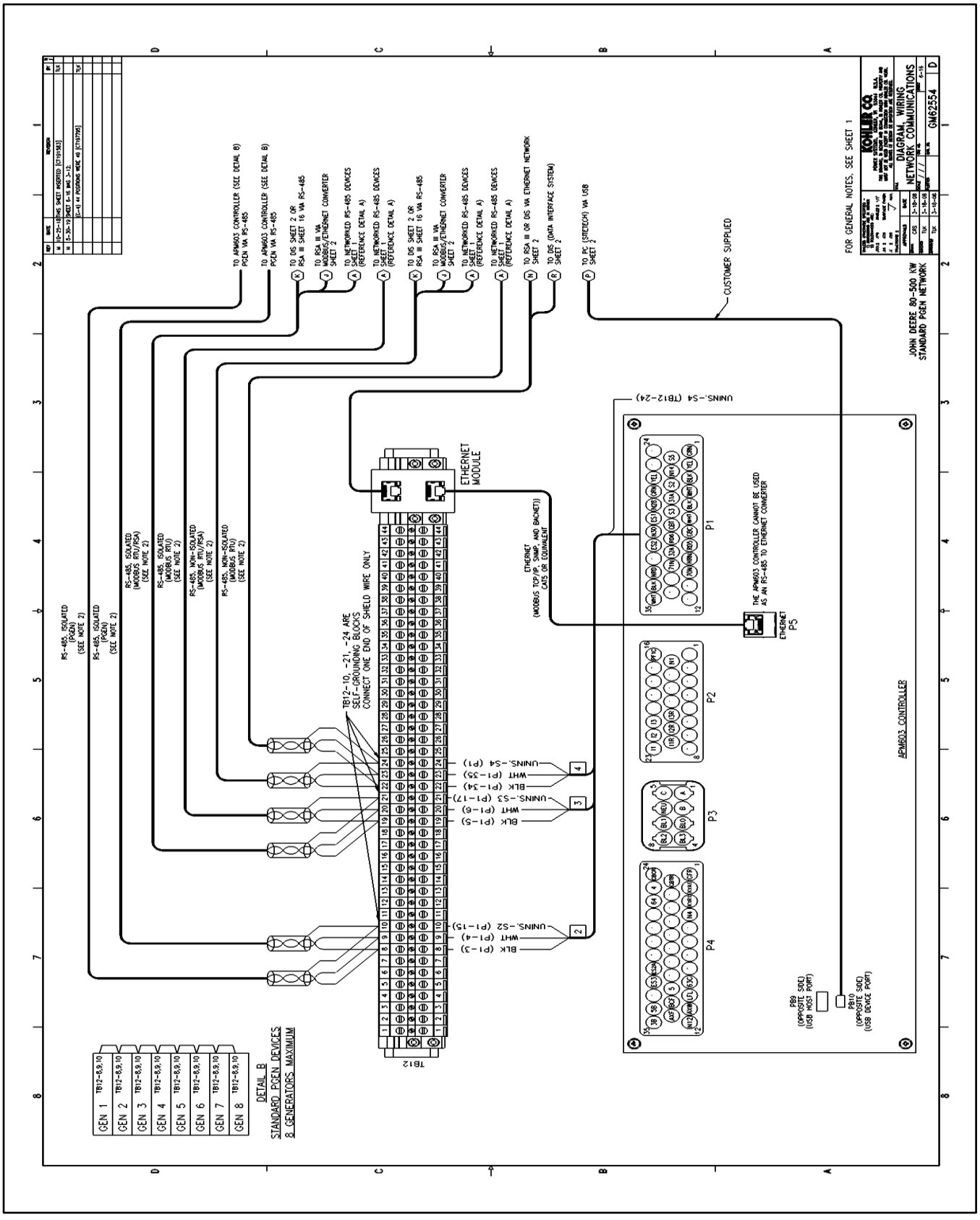

Figure 42 Wiring Diagram, Network Communications, GM62554, Sheet 6

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