POWELL



01.4IB.60111 Powell Ground Protect Plus™ Communication Manual

Communication Manual with Modbus Memory Map

Powered by Safety®

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Signal Words

As stated in ANSI Z535.4-2007, the signal word is a word that calls attention to the safety sign and designates a degree or level of hazard seriousness. The signal words for product safety signs are **"Danger"**, **"Warning"**, **"Caution"** and **"Notice"**. These words are defined as:

⚠ DANGER

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

CAUTION

CAUTION, used without the safety alert symbol, is used to address practices not related to personal injury.

NOTICE

NOTICE is used to address practices not related to personal injury.

Qualified Person

For the purposes of this manual, a qualified person, as stated in NFPA 70E®, is one who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved. In addition to the above qualifications, one must also be:

1. trained and authorized to energize, deenergize, clear, ground, and tag circuits and equipment in accordance with established safety practices.
2. trained in the proper care and use of personal protective equipment (PPE) such as rubber gloves, hard hat, safety glasses or face shields, flash clothing, etc., in accordance with established safety practices.
3. trained in rendering first aid if necessary.

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Ch 1 General Information

⚠ WARNING

The equipment described in this document may contain high voltages and currents which can cause death or serious injury.

The equipment is designed for use, installation, and maintenance by knowledgeable users of such equipment having experience and training in the field of high voltage electricity. This document and all other documentation shall be fully read, understood, and all warnings and cautions shall be abided by. If there are any discrepancies or questions, the user shall contact Powell immediately at 1.800.480.7273.

⚠ WARNING

Prior to adjustments, servicing, maintenance, or any act requiring the operator to make physical contact with the equipment, the power source must be disconnected and the equipment grounded. Failure to do so may result in death or serious injury.

NOTICE

The information in this instruction bulletin is not intended to explain all details or variations of the Powell equipment, nor to provide for every possible contingency or hazard to be met in connection with installation, testing, operation, and maintenance of the equipment. For additional information and instructions for particular problems, which are not presented sufficiently for the user's purposes, contact Powell at 1.800.480.7273.

NOTICE

Powell reserves the right to discontinue and to change specifications at any time without incurring any obligation to incorporate new features in products previously sold.

A. Scope

This manual describes the communication ports of the Powell Ground Protect Plus™ Low Voltage High Resistance Grounding System and the information that is accessible from them. The manual and the terminology used, assume that the user has a basic understanding of the communication technologies and protocols implemented.

B. Purpose

The information in this instruction bulletin is intended to provide information required to properly operate and maintain the Communications Controller for Powell Ground Protect Plus.

This instruction bulletin provides:

1. Safety guidelines
2. General descriptions of the operation and maintenance of the Powell Ground Protect Plus Communications Controller
3. Instructions for installation and placing the Powell Ground Protect Plus Communications Controller into service
4. Instructions for part replacement
5. Information for ordering renewal parts
6. Procedure for critical adjustments
7. Illustrations, photographs, and description of the Powell Ground Protect Plus Communications Controller

The illustrations contained in this document may not represent the exact construction details of each particular type of Powell Ground Protect Plus Communications Controller. The illustrations in this document are provided as general information to aid in showing component locations only.

All illustrations and photos are shown using deenergized equipment.

⚠ WARNING

Follow the appropriate safety precautions while handling any of the equipment. Failure to do so may result in serious death or serious injury.

To the extent required, the products described herein meet the applicable ANSI, IEEE, and NEMA Standards; however, no such assurance is given with respect to local codes and ordinances which may vary greatly.

C. Instruction Bulletins Available Electronically

NOTICE

Changes to the instruction bulletin may be implemented at any time and without notice. Go to powellind.com to ensure use of the current instruction bulletin for Powell equipment.

For more information visit powellind.com. To contact the Powell Service Division call 1.800.480.7273 or 713.944.6900, or email info@powellservice.com.

For specific questions or comments pertaining to this instruction bulletin email documents@powellind.com with the IB number in the subject line.

D. Associated Bulletins

- 01.4IB.60110 Powell Ground Protect Plus™

Ch 2 Safety

A. Safe Work Condition

The information in Section A is quoted from *NFPA 70E 2012 - Article 120, 120.1 Establishing an Electrically Safe Work Condition.*

120.1 Process of Achieving an Electrically Safe Work Condition

1. Determine all possible sources of electrical supply to the specific equipment. Check applicable up-to-date drawings, diagrams, and identification tags.

2. After properly interrupting the load current, OPEN the disconnecting device(s) for each source.

3. Wherever possible, visually verify that all blades of the disconnecting devices are fully OPEN or that drawout type circuit breakers are withdrawn to the fully disconnected position.

4. Apply lockout/tagout devices in accordance with a documented and established policy.

5. Use an adequately rated voltage detector to test each phase conductor or circuit part to verify they are deenergized. Test each phase conductor or circuit part both phase-to-phase, and phase-to-ground. Before and after each test, determine that the voltage detector is operating satisfactorily.

   Informational Note: See ANSI/ISA-61010-1 (82.02.01)/UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements*, for rating and design requirements for voltage measurement and test instruments intended for use on electrical systems 1000 V and below.

6. Where the possibility of induced voltages or stored electrical energy exists, ground the phase conductors or circuit parts before touching them. Where it could be reasonably anticipated that the conductors or circuit parts being deenergized could contact other exposed energized conductors or circuit parts, apply ground connecting devices rated for the available fault duty.

B. Safety Guidelines

Study this instruction bulletin and all other associated documentation before uncrating the high resistance ground system.

Each user has the responsibility to instruct and supervise all personnel associated with usage, installation, operation, and maintenance of this equipment on all safety procedures. Furthermore, each user has the responsibility of establishing a safety program for each type of equipment encountered.

It is mandatory that the following rules be observed to ensure the safety of personnel associated with usage, installation, operation, and maintenance of these High Resistance Ground Systems.

The safety rules in this instruction bulletin are not intended to be a complete safety program. The rules are intended to cover only some of the important aspects of personnel safety related to high resistance ground system.

C. General

1. Only supervised and qualified personnel trained in the usage, installation, operation, and maintenance of the high resistance ground system shall be allowed to work on this equipment. It is mandatory that this instruction bulletin, any supplements, and service advisories be studied, understood, and followed.

2. Maintenance programs must be consistent with both customer experience and manufacturer's recommendations, including service advisories and instruction bulletin(s). A well planned and executed routine maintenance program is essential for circuit breaker's reliability and safety.

3. Service conditions and applications shall also be considered in the development of safety programs. Variables include ambient temperature; humidity; and any adverse local conditions including excessive dust, ash, corrosive atmosphere, vermin and insect infestations.

D. Specific

When operating the High Resistance Ground System safety precautions must be observed. **Improper use can result in death, serious personal injury, or damage to the equipment**. It is important for the user to develop specific and safe operating procedures to be observed when using the High Resistance Ground System.

E. Safety Labels

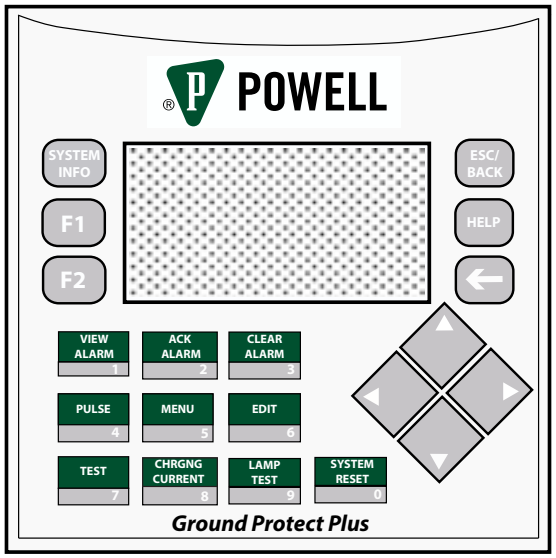
The equipment described in this document has **DANGER**, **WARNING, CAUTION,** and instruction labels attached to various locations. All equipment **DANGER**, **WARNING, CAUTION,** and instruction labels shall be observed when the circuit breaker is handled, operated, or maintained.

NOTICE

Warning and Caution labels are located in various places. Do not remove or deface any of these warning/caution labels.

Ch 3 Communication Ports

Figure 1 Protect Plus Controller



This section presents information on the communication ports available on the controller. Changes to the controller's communications ports should only be made by qualified technicians. The controller is provided with an RS-485 port by default and has an option for an Ethernet port. The ports are as follows:

A. Port 1

This port is configured as RS-485. When power cycles, the controller will load the latest port 1 "RS-485 Network ID". Port 1 is configured as follows:

1. 1 channel RS-485, no galvanic isolation, 300 to 115,200 bps baud rate (default 115,200), -7 to +12VDC differential maximum control voltage, shielded twisted pair cable (EIA 485) and a maximum cable length of 4000 feet (1200 meters).
2. RJ-11 connector pin-out, assuming pin 1 on bottom left and pin 6 on top left when looking at port.
   a. Flow control signals are not used:
      i. Pin #1: A signal (+).
      ii. Pin #2: 0V reference.
      iii. Pin #3: TXD signal.
      iv. Pin #4: RXD signal.
      v. Pin #5: 0V reference.
      vi. Pin #6: B signal (-).
3. Signals are related to the controllers 0V; the same 0V is used by the power supply.
4. This port is not isolated. If the controller is used with a non-isolated external device, avoid potential voltage that exceeds ±10V.

B. Port 2

Ethernet TCP/IP, RJ45 type connection, 10/100Mbps transmission speed, star network topology based on external hub/switch, Category 5 shielded twisted pair with a drop line length of up to 333 feet (100 meters) controller to hub/switch.

1. RJ45 connector pin-out
   a. Pin #1: T+ = positive transmit signal.
   b. Pin #2: T- = negative transmit signal.
   c. Pin #3: R+ = positive receive signal.
   d. Pin #6: R- = negative receive signal.

2. Ethernet LEDs
   a. Green LED (LNK): ON when link exists.
   b. Yellow LED (ACT): Blinks during RX/TX.

c. Controller to hub/switch connection

Table A Controller to Hub/Switch Connection

Controller			Hub/Switch	
Pin #	**Function**		**Pin #**	**Function**
1	T+	to	1	T+
2	T-	to	2	T-
3	R+	to	3	R+
6	R-	to	6	R-

Ch 4 Communication Port Settings

Controller communications to an external customer network is either by MODBUS RTU via RS-485 on controller port 1 or via Ethernet TCP/IP on controller Port 2. Modbus TCP/IP is via Ethernet socket 2, port 502.

A. Port 1

The default status of controller port 1 is MODBUS RTU via RS-485. The default network ID number is 64. The default baud rate is 115,200.

To change the port 1 communication parameters for the controller, use the following procedure:

1. If the password is not already disabled or entered, press the "EDIT" key and follow the password entry instructions.
2. On the "CommPort1" screen and using the arrow keys, select either "Port Setting" or "RS-485 Network ID" for editing. Edit per the procedure in ***Ch 13 Controller Setup, D. Data Entry*** of the *Powell Ground Protect Plus Instruction Bulletin*. The "RS-485 Network ID" value is saved to the "RS485 Parameters" data table without having to leave the screen. The display shows the configuration of port 1.

   Note: *The settings available are only from 64 to 127. This is due to the controller reserving 0 to 63 for Fieldbus communications. These communications are not supported by the Ground Protect Plus™.*

B. Port 2

The IP address for the controller uses the IP4 protocol. Each part is made up of four octets with decimal points between each octet. The customer must provide an IP address, subnet mask and gateway mask for communicating on the customer Ethernet network.

A default set of values is preloaded in the data table "TCP-IP Init". When power cycles, the controller will load the latest port 2 configuration. The default/updated values can be viewed from the "Ethernet Port" screen.

To change the Ethernet communication parameters for the controller, use the following procedure:

1. If the password is not already disabled or entered, press the "EDIT" key and follow the password entry instructions.
2. On the "Ethernet Port" screen and using the arrow keys, select any of the "IP address", "Subnet mask" or "Gateway mask" values for editing. Edit per the procedure in ***Ch 13 Controller Setup, D. Data Entry*** of *Powell Ground Protect Plus Instruction Bulletin*. Upon leaving the screen, all values are saved to the "TCP-IP Init" data table. These values will be reloaded into the controller any time power cycles.

Ch 5 Data Tables

A. Alarms

Table B Alarms	
No. Columns:	5
No. Rows:	200
Column 1:	"Alarm Type", integer; this is the code used by the program to determine which screen to display when the current record is being accessed.
Column 2:	"Alarm Value", float; this is the value of the variable that generated the alarm.
Column 3:	"Date", string, 9 bytes; the date that the alarm occurred.
Column 4:	"Time", string, 9 bytes; the time that the alarm occurred. (24-hour clock)
Column 5:	"Alarm Acknowledge", integer; 0 – alarm acknowledged, 1 – alarm not acknowledged. Directs alarm display on whether to display "Alarm Acknowledged" tag.

Table C Alarm Type and Description	
Alarm Type	**Alarm Description**
11	Voltage Above Limit - "Warning!! Voltage across NGR has exceeded maximum alarm value
12	Voltage Below Limit - "Warning!! Voltage across NGR is below the minimum alarm value."
21	Current Above Limit - "Warning!! Current through NGR has exceeded maximum alarm value."
22	Current Below Limit - "Warning!! Current through NGR is below the minimum alarm value."
71	Phase A Fault - "Warning!! A single-line-to-ground fault has occurred on Phase A."
72	Phase B Fault - "Warning!! A single-line-to-ground fault has occurred on Phase B."
73	Phase C Fault - "Warning!! A single-line-to-ground fault has occurred on Phase C."
113	NGR Failure - "Warning!! An open circuit has occurred in the NGR. An ungrounded system condition may result."

B. Customer Calculated Values

Table D Customer Calculated Values	
No. Columns:	1
No. Rows:	1
Column 1:	"System Charging Current", float; this is the value calculated when the "CHRGNG CURRENT" key is pressed on the front panel.

C. Customer Password

Table E Customer Password	
No. Columns:	1
No. Rows:	1
Column 1:	"Customer Password", integer. This value is factory set to "1000" and is user editable. The customer password is limited to the range "1000" to "9999".

D. Customer System Data

Table F Customer System Data	
No. Columns:	10
No. Rows:	1
Column 1:	"Ground Fault Alarm Level", float; this is the value of the current through the sensing resistor/NGR transducer used in the NGR open-circuit detection logic. This value is user editable.
Column 2:	"Sensing Resistor Voltage Alarm Level – short circuit", float; this is the value of voltage across the sensing resistor used in the NGR open-circuit detection logic during a short circuit condition. This value is set based upon the system rated voltage. This value is user editable.
Column 3:	"Sensing Resistor Voltage Alarm Level – normal", float; this is the value of voltage across the sensing resistor used in the NGR open-circuit detection logic during a normal system conditions. This value is defaulted to 10% of the value in column 2. This value is user editable.
Column 4:	"System Rated Voltage", float; this is the rated voltage of the customer's system. This value is user editable.
Column 5:	"System Rated Current", float; this is the rated current of the customer's system. This value is user editable.
Column 6:	"NGR Maximum Voltage", float; this is the value at which the system enters into an overvoltage condition. An alarm is generated when this occurs. This value is user editable.
Column 7:	"NGR Minimum Voltage", float; this is the value at which the system enters into an undervoltage condition. An alarm is generated when this occurs. This value is user editable.
Column 8:	"NGR Maximum Current", float; this is the value at which the system enters into an overcurrent condition. An alarm is generated when this occurs. This value is user editable.
Column 9:	"NGR Minimum Current", float; this is the value at which the system enters into an undercurrent condition. An alarm is generated when this occurs. This value is user editable.
Column 10:	"LVM Mode", Boolean (0 or 1); this value controls the operation of the line voltage monitoring subsystem. When deactivated, the line voltage monitoring subsystem will not identify the faulted phase. This value is user editable.

E. Events

Table G Events	
No. Columns:	4
No. Rows:	200
Column 1:	"Event Type", integer; this is the code used by the program to determine which screen to display when the current record is being accessed.
Column 2:	"Date", string, 9 bytes; the date that the event occurred.
Column 3:	"Time", string, 9 bytes; the time that the event occurred.
Column 4:	"Event Acknowledge", integer; 0 – event acknowledged, 1 – event not acknowledged. Directs event display on whether to display "Event Acknowledged" tag or not.

Table H Event Type and Description	
Event Type	**Event Description**
74	Ground Faults Cleared - "Phase-to-ground faults no longer detected. Any undetected faults may still be on system."
75	System Charging Current - "System charging current has been calculated. View Parameters screen for calculation result."
76	Test Resistor Connected - "Test Resistor has been connected."
101	Voltage Within Limits - "Voltage across the NGR has returned to normal."
102	Current Within Limits - "Current through the NGR has returned to normal."
111	Pulse Start - "Pulsing of faulted system through NGR has started."
112	Pulse Stop - "Pulsing of faulted system through NGR has stopped."
200	Password Changed - "Password has been changed."
201	Password Disabled - "Password disabled. Protection removed from system. Unauthorized user access allowed."
202	Password Enabled - "Password enabled. Protection returned to system. Unauthorized user access not allowed."
203	Lamp Event - "Front Panel Lamps and Horn tested."
250	LVM Enabled - "Loss of Voltage Monitoring System has been Enabled."
251	LVM Disabled - "Loss of Voltage Monitoring System has been Disabled."

F. Table Counters

Table I Table Counters	
No. Columns:	2
No. Rows:	1
Column 1:	"Alarm Counter", integer; this counter points to the next record to be filled in the "Alarms" table. This value is not user editable.
Column 2:	"Event Counter", integer; this counter points to the next record to be filled in the "Events" table. This value is not user editable.

G. Timers

Table J Timers	
No. Columns:	3
No. Rows:	1
Column 1:	"Ground Fault TD", integer; this is the time delay, in multiples of 10 milliseconds, before the PLC records alarms and/or events based on system conditions. This value is user editable from the "Parameters" screen.
Column 2:	"Pulse Rate", integer; this is the rate, in multiples of 10 milliseconds, that the pulse contactor cycles CLOSED and OPEN. This value is user editable from the "Parameters" screen.
Column 3:	"Alarm Resend Timer", long integer; this is the time delay, in multiples of 10 milliseconds, before alarms are resent if the VIEW ALARM button has not been pressed.

H. TCP-IP Init

Table K TCP-IP Init	
No. Columns:	12
No. Rows:	1
Column 1-4:	"IP octet 1" through "IP octet 4". These are the 4 octets that make up the IP address in the IP4 format. All values must be between 0 and 255.
Column 5-8:	"Subnet octet 1" through "Subnet octet 4". These are the 4 octets that make up the Sub Net mask. All values must be between 0 and 255.
Column 9-12:	"Gateway octet 1" through "Gateway octet 4". These are the 4 octets that make up the Gateway mask. All values must be between 0 and 255.

I. PPN Name

Table L PPN Name	
No. Columns:	1
No. Rows:	1
Column 1:	"PPN Name", 20 character string containing the Ground Protect Plus™ controller name. This value, combined with the information from table "TCP-IP Init", uniquely identifies each controller on the customer's Ethernet. Both items are required to access the controller via Ethernet. ***NOTE:*** *It is highly recommended that this value not be changed as the controller may lose communications.*

J. RS-485 Parameters

Table M RS-485 Parameters	
No. Columns:	4
No. Rows:	1
Column 1:	"Network ID", integer; this number identifies a device on the RS-485 network. This value must be between 64 and 127 to use MODBUS RTU over the RS-485 network.
Column 2:	"Time Out", integer; this is the amount of time a main controller waits for answer from a secondary controller. This value is defaulted to 100. Since the Ground Protect Plus is a secondary controller, this value is only provided to properly initialize the MODBUS RTU protocol.
Column 3:	"Retries", integer; this is the number of times the Ground Protect Plus controller will try to send a message. This value must be between 1 and 10 and is defaulted to 3.
Column 4:	"Baud Rate ID", integer; this value identifies the current baud rate for the RS-485 port. This value must be between 1 and 10 and is defaulted to 10.

Table N Baud Rates	
Baud Rate ID	**Baud Rate**
1	300
2	600
3	1200
4	2400
5	4800
6	9600
7	19200
8	38400
9	57600
10	115200

Ch 6 Data Table Access via Modbus

A. Introduction

The data tables in the controller are accessible via Modbus. This section describes the information necessary to access these data tables.

The controller's Ethernet uses a star topology. A central hub, or switch, is used to connect multiple controllers to the user's Ethernet network. The connection from the hub to each controller is limited to 100 meters. A detailed explanation of Ethernet, TCP/IP and IP addressing is beyond the scope of this document. ***Ch 6 Data Table Access Via Modbus,* B. Customer System Data** describes the requirements for using Ethernet TCP/IP with the controller in more detail. Controller to controller communications is not implemented in the Ground Protect Plus™.

B. Using Modbus To Access Data Tables

The user can access the controller's data tables using Modbus. The user should not access any other items within the controller. Modifying internal controller values may cause the controller to malfunction, compromising its operation and user safety.

The controller supports RTU (binary) transmission mode over an RS-485 network and TCIP/IP protocols over an Ethernet network. ***Ch 6 Data Table Access Via Modbus,* B. Using Modbus to Access Data Tables** gives a detailed description of the data tables.

Data tables Alarms, "Customer Calculated Values", "Events", "Table Counters", "TCP-IP Init" and "PPN Name" should only be read from, not written to. Data tables "Customer Password", "Customer System Data" and "Timers" are both read and write compatible.

C. Modbus Addressing Tables

These tables are to be used when assembling the Modbus addresses for the data table variables provided in the following sections.

Table O Modbus Addresses			
Coils		**Modbus Command Number**	
Pointer Value From:	Operand Type	Read	Write
0000h	MB 0-2999	#01 Read Coils	#15 Force Coils
6000h	I (input, read only)		

Table P Modbus Addresses (cont.)				
Registers			**Modbus Command Number**	
Pointer Value From:	Operand Type	Register Size	Read	Write
0000h	MI	16 bit	#03 Read Holding Registers	#16 Preset Holding Registers
4000H	MF	32 bit		
7700h	ML	32 bit		

D. Customer Password

The following table lists controller variables accessible to Modbus.

Table Q Customer Password		
Operand Name	**Data Type**	**Controller Variable**
Customer Password	Integer	MI41 - System Password

E. Customer System Data

Table R Customer System Data		
Operand Name	**Data Type**	**Controller Variable**
Sensing Resistor Voltage Alarm Level – short circuit	Float	MF7 - Sensing Resistor Voltage Alarm Setting – short circuit
Sensing Resistor Voltage Alarm Level - normal	Float	MF4 - Sensing Resistor Voltage Alarm Setting - normal
System Rated Voltage	Float	MF10 - System Rated Voltage
System Rated Current	Float	MF9 - System Rated Current
NGR Maximum Voltage	Float	MF11 - NGR Maximum Voltage
NGR Minimum Voltage	Float	MF12 - NGR Minimum Voltage
NGR Maximum Current	Float	MF13 - NGR Maximum Current
NGR Minimum Current	Float	MF14 - NGR Minimum Current
LVM Mode	Boolean (0 or 1)	MB56 – LVM Mode

F. Timers

The following table lists controller variables accessible to Modbus

Table S Timers		
Operand Name	**Data Type**	**Controller Variable**
Ground Fault TD	Integer	MI70 - Ground Fault TD
Pulse Rate	Integer	MI71 - Pulse Rate
Alarm Resend Timer	Long Integer	ML0 – Alarm resend TD

G. Customer Calculated Values

The following table lists controller variables accessible to Modbus.

Table T Customer Calculated Values		
Operand Name	**Data Type**	**Controller Variable**
System Charging Current	Float	MF15 - System Charging Current

H. Table Counter

Table U Table Counter		
Operand Name	**Data Type**	**Controller Variable**
Alarm Counter	Integer	MI12 - Alarm Table Row Number
Event Counter	Integer	MI16 - Event Table Row

I. TCT-IP Init

The following table lists controller variables accessible to Modbus.

Table V TCP-IP Init		
Operand Name	**Data Type**	**Controller Variable**
IP octet 1-4	Integer	MI161, MI162, MI163, MI164
Subnet octet 1-4	Integer	MI165, MI166, MI167, MI168
Gateway octet 1-4	Integer	MI169, MI170, MI171, MI172

If any of these values are updated via Modbus, the unit should be rebooted to load the values into the controller memory.

J. PPN Name

For this table, the user must download numeric values representing ASCII characters to the variables within the program. The PPN Name is limited to a length of 20 characters; each character requires 8 bits for storage. Each MI type variable consists of 16 bits, allowing the storage of 2 characters. The character string is stored in MI250 to MI259. For each character pair, the first character is stored in the lower 8 bits and the second character is stored in the upper 8 bits. To determine the numeric codes to download to the PLC or to translate uploaded codes, follow the procedure below.

This table lists the hexadecimal codes for each ASCII character that can be used in naming the unit.

Table W PPN Name

Text	Hex	Text	Hex	Text	Hex	Text	Hex
A	41	a	61	space	20	{	7B
B	42	b	62	0	30	[	5B
C	43	c	63	1	31	}	7D
D	44	d	64	2	32	]	5D
E	45	e	65	3	33	|	7C
F	46	f	66	4	34	\	5C
G	47	g	67	5	35	:	3A
H	48	h	68	6	36	;	3B
I	49	i	69	7	37	"	22
J	4A	j	6A	8	38	'	27
K	4B	k	6B	9	39	<	3C
L	4C	l	6C	~	7E	,	2C
M	4D	m	6D	`	60	>	3E
N	4E	n	6E	!	21	.	2E
O	4F	o	6F	@	40	?	3F
P	50	p	70	#	23	/	2F
Q	51	q	71	$	24		
R	52	r	72	%	25		
S	53	s	73	^	5E		
T	54	t	74	&	26		
U	55	u	75	*	2A		
V	56	v	76	(	28		
W	57	w	77	)	29		
X	58	x	78	_	5F		
Y	59	y	79	-	2D		
Z	5A	z	7A	+	2B		
				=	3D		

Example: send "Ground Protect Plus™" to controller.

MI250 = "Pu", MI251 = "ls", MI252 = "er", MI253 = "Pl", MI254 = "us", MI255 = ".N" and MI256 = "et".

MI250 low byte is "P" and MI250 high byte is "u". From the chart above, the hex code for "P" is 50H and the hex code for "u" is 75H. Combining, the value of MI250 is 7550H. Convert this to binary. The binary for 7H is "0111" and for 5H is "0101". The binary number is "011101010101000". Converting binary to decimal, you add $2^{14} + 2^{13} + 2^{12} + 2^{10} + 2^{8} + 2^{6} + 2^{4}$ = 16,384 + 8,192 + 4,096 + 1,024 + 256 + 64 + 16 = 30032. This is the value for MI250 that would be sent to the controller.

MI251 low byte is "l" and high byte is "s". The hex value for MI251 is 736CH. The binary value is "0111001101101100" and the decimal value is 29548. This is the value for MI251 that would be sent to the controller.

MI252 low byte is "e" and high byte is "r". The hex value for MI252 is 7265H. The binary value is "0111001001100101" and the decimal value is 29285.

MI253 low byte is "P" and high byte is "l". The hex value for MI253 is 6C50H. The binary value is "0101110001010000" and the decimal value is 27728.

MI254 through MI256 would be set up in a similar manner. MI257 through MI259 would need to be sent null strings, decimal value "0", so that stray or previous characters are blanked out.

If these values are updated via Modbus, the unit should be rebooted to load the values into the controller memory.

The following table lists controller variables accessible to Modbus.

Table X Controller Variables Accessible to Modbus

Operand Name	Data Type	Controller Variable
PPN Name	String, 20 characters	MI250 to MI259 - PPN Name

K. Data Table Alarms

The following table lists controller variables accessible to Modbus.

Table Y Alarms		
Operand Name	**Data Type**	**Controller Variable**
Alarm Type	Integer	MI50 - Alarm Type - Display
Alarm Value	Float	MF16 - Alarm Value - Display
Date	String, 9 characters	MI51 - MI55 - Date - Display
Time	String, 9 characters	MI56 - MI60 - Time - Display
Alarm Acknowledge	Integer	MI61 - Alarm Acknowledge - Display

The values MI50, MF16 and MI61 are read in the same manner as in other data tables. For MI61, 0 = acknowledged, 1 = not acknowledged. Each string, MI51 - MI55 and MI56 - MI60, is treated in a manner similar to the "PPN Name" table. The same ASCII chart applies.

The date string is represented as mm/dd/yy plus a null (0) character. MI55 will always have a value of zero. MI51 stores the decimal equivalent of "mm", MI52 stores "/d", MI53 stores "d/" and MI54 stores "yy".

The time string is represented as hh:mm:ss plus a null (0) character. MI60 will always have a value of zero. MI56 stores the decimal equivalent of "hh", MI57 stores ":m", MI58 stores "m:" and MI59 stores "ss".

In translating the values from decimal to ASCII upon downloading, remember that the first character is stored in the lower 8 bits and the second character is stored in the upper 8 bits.

L. Reading Data Table Alarms

Similar to the "Events" data table and unlike the other data tables, the "Alarms" data table is made up of multiple rows. Each row must be read separately by the calling program. To do this, each request must force coil MB50, the "read alarm" control bit. Each request must also include MI450 (integer), the row being read. Coil MB50 must be forced for each read request. The maximum number of rows to read is the value for MI12 in the "Table Counters" data table. This request will be ignored if the user is reviewing the alarms at the controller faceplate.

The sample command sequence for reading the alarm table is as follows:

Table Z Reading Alarms

Command	Variable	Action
#03	MI12	Read number of alarms
#16	MI460	Write row number to read
#15	MB50	Force coil to change state
#03	MI50	Read Alarm Type
#03	MF16	Read Alarm Value
#03	MI51 - MI55	Read Alarm Date Information
#03	MI56 - MI60	Read Alarm Time Information
#03	MI61	Read Alarm Acknowledgement status

M. Data Table Events

The following table lists controller variables accessible to Modbus.

Table AA Events

Operand Name	Data Type	Controller Variable
Event Type	Integer	MI62 - Event Type-Display
Date	String, 9 characters	MI51-MI55 - Date-Display
Time	String, 9 characters	MI56-MI60 - Time-Display
Event Acknowledge	Integer	MI63 - Event Acknowledge- Display

The values MI62 and MI63 are read in the same manner as in other data tables. For MI63, 0 = acknowledged, 1 = not acknowledged. Each string, MI51- MI55 and MI56 - MI60, is treated in a manner similar to the "PPN Name" table. The same ASCII chart applies.

The date string is represented as mm/dd/yy plus a null (0) character. MI55 will always have a value of zero. MI51 stores the decimal equivalent of "mm", MI52 stores "/d", MI53 stores "d/" and MI54 stores "yy".

The time string is represented as hh:mm:ss plus a null (0) character. MI60 will always have a value of zero. MI56 stores the decimal equivalent of "hh", MI57 stores ":m", MI58 stores "m:" and MI59 stores "ss".

In translating the values from decimal to ASCII upon downloading, remember that the first character is stored in the lower 8 bits and the second character is stored in the upper 8 bits.

N. Reading Data Table Events

Similar to the "Alarms" data table and unlike the other data tables, the "Events" data table is made up of multiple rows. Each row must be read separately by the calling program. To do this, each request must force coil MB51, the "read event" control bit. Each request must also include MI460 (integer), the row being read. Coil MB51 must be forced for each read request. The maximum number of rows to read is the value for MI16 in the "Table Counters" data table. This request will be ignored if the user is reviewing the events at the controller faceplate.

The sample command sequence for reading the event table is as follows:

Table AB Reading Events

Command	Variable	Action
#03	MI1	Read number of events
#16	MI460	Write row number to read
#15	MB51	Force coil to change state
#03	MI62	Read event type
#03	MI51- MI55	Read event date information
#03	MI56- MI60	Read event time information
#03	MI63	Read event acknowledgement status

O. Data Table RS-485 Parameters

The following table lists controller variables accessible to Modbus.

Table AC RS-485 Parameters

Operand Name	Data Type	Controller Variable
Network ID	Integer	MI175
Time Out	Integer	MI176
Retries	Integer	MI177
Baud Rate ID	Integer	MI178

It is recommended that the values in data table "RS485 Parameters" not be changed via Modbus.

Ch 7 Modbus Memory Map

A. Introduction

To facilitate communications with external monitoring and control devices, the Ground Protect Plus™ controller uses the Modbus protocol. This protocol is provided in two implementations. For RS-485 networks, the controller uses the Modbus RTU protocol. The Modbus ASCII protocol is not available. For Ethernet-based networks, the controller uses Modbus TCP/IP. A thorough discussion of these protocols is beyond the purpose of this document. Since each customer installation will be different, the customer is referred to the specific installation documents for further details.

B. Modbus Memory Map

The Modbus memory map lists the program variable, the variable type (coil or register), variable name, Modbus address, register size, read command and write command. Based upon this information, it is the customer's responsibility to properly configure the message request to the controller. All addresses are in hexadecimal (h) format.

Table AD Modbus Memory Map

Variable	Variable Type	Variable Name	Modbus Address	Read	Write
MB0	Coil	voltage alarm bit	0000h	#01	NR
MB1	Coil	current alarm bit	0001h	#01	NR
MB2	Coil	phase voltage loss bit	0002h	#01	NR
MB4	Coil	voltage above maximum value	0004h	#01	NR
MB5	Coil	voltage below minimum value	0005h	#01	NR
MB6	Coil	current below minimum value	0006h	#01	NR
MB7	Coil	current above maximum value	0007h	#01	NR
MB13	Coil	phase A faulted	000Dh	#01	NR
MB14	Coil	phase B faulted	000Eh	#01	NR
MB15	Coil	phase C faulted	000Fh	#01	NR
MB21	Coil	NGR failed	0015h	#01	NR
MB50	Coil	Read Alarm Control Bit	0032h	NA	#15
MB51	Coil	Read Event Control Bit	0033h	NA	#15
MB80	Coil	MODBUS Pulse Function Control Bit	0050h	#01	#15
I0	Coil	Phase A Fault Monitor Input	6000h	#01	NA
I1	Coil	Phase B Fault Monitor Input	6001h	#01	NA
I2	Coil	Phase C Fault Monitor Input	6002h	#01	NA

Table AE Modbus Memory Map (cont.)						
Variable	**Variable Type**	**Variable Name**	**Modbus Address**	**Register Size**	**Read**	**Write**
MI12	Register	Alarm Table Row Number	000C$_h$	16 bit	#03	NR
MI16	Register	Event Table Row Number	0010$_h$	16 bit	#03	NR
MI23	Register	Pulse Rate	0017$_h$	16 bit	#03	#16
MI24	Register	Ground Fault Time Delay	0018$_h$	16 bit	#03	#16
MI25	Register	Alarm Resend Timer	0019$_h$	16 bit	#03	#16
MI41	Register	Customer Password	0029$_h$	16 bit	#03	#16
MI50	Register	Alarm Type	0032$_h$	16 bit	#03	NR
MI51	Register	Date - Characters 1 & 2	0033$_h$	16 bit	#03	NR
MI52	Register	Date - Characters 3 & 4	0034$_h$	16 bit	#03	NR
MI53	Register	Date - Characters 5 & 6	0035$_h$	16 bit	#03	NR
MI54	Register	Date - Characters 7 & 8	0036$_h$	16 bit	#03	NR
MI55	Register	Date - Characters 9, null	0037$_h$	16 bit	#03	NR
MI56	Register	Time - Characters 1 & 2	0038$_h$	16 bit	#03	NR
MI57	Register	Time - Characters 3 & 4	0039$_h$	16 bit	#03	NR
MI58	Register	Time - Characters 5 & 6	003A$_h$	16 bit	#03	NR
MI59	Register	Time - Characters 7 & 8	003B$_h$	16 bit	#03	NR
MI60	Register	Time - Characters 9, null	003C$_h$	16 bit	#03	NR
MI61	Register	Alarm Acknowledge	003D$_h$	16 bit	#03	#16
MI62	Register	Event Type	003E$_h$	16 bit	#03	NR
MI63	Register	Event Acknowledge	003F$_h$	16 bit	#03	#16
MI161	Register	IP Octet 1	00A1$_h$	16 bit	#03	NR
MI162	Register	IP Octet 2	00A2$_h$	16 bit	#03	NR
MI163	Register	IP Octet 3	00A3$_h$	16 bit	#03	NR
MI164	Register	IP Octet 4	00A4$_h$	16 bit	#03	NR
MI165	Register	Subnet Octet 1	00A5$_h$	16 bit	#03	NR
MI166	Register	Subnet Octet 2	00A6$_h$	16 bit	#03	NR
MI167	Register	Subnet Octet 3	00A7$_h$	16 bit	#03	NR
MI168	Register	Subnet Octet 4	00A8$_h$	16 bit	#03	NR
MI169	Register	Gateway Mask Octet 1	00A9$_h$	16 bit	#03	NR
MI170	Register	Gateway Mask Octet 2	00AA$_h$	16 bit	#03	NR
MI171	Register	Gateway Mask Octet 3	00AB$_h$	16 bit	#03	NR
MI172	Register	Gateway Mask Octet 4	00AC$_h$	16 bit	#03	NR
MI175	Register	RS-485 Network ID	00AF$_h$	16 bit	#03	NR
MI176	Register	RS-485 Time Out	00B0$_h$	16 bit	#03	NR
MI177	Register	RS-485 Retries	00B1$_h$	16 bit	#03	NR
MI178	Register	Baud Rate ID	00B2$_h$	16 bit	#03	NR

Table AF Modbus Memory Map (cont.)						
Variable	**Variable Type**	**Variable Name**	**Modbus Address**	**Register Size**	**Read**	**Write**
MI450	Register	Alarm Row Being Accessed Via Modbus	01C2h	16 bit	NA	#16
MI460	Register	Event Row Being Accessed Via Modbus	01CCh	16 bit	NA	#16
ML0	Register	Alarm Resend Timer	7000h	32 bit	#03	#16
MF0	Register	Scaled NGR Voltage	4000h	32 bit	#03	NR
MF1	Register	Scaled NGR Current	4002h	32 bit	#03	NR
MF2	Register	Scaled Test Resistor Current	4004h	32 bit	#03	NR
MF3	Register	Scaled Sensing Resistor Voltage	4006h	32 bit	#03	NR
MF4	Register	Sensing Resistor Voltage Alarm Setting – normal	4008h	32 bit	#03	#16
MF7	Register	Sensing Resistor Voltage Alarm Setting	400Eh	32 bit	#03	#16
MF9	Register	System Rated Current	4012h	32 bit	#03	#16
MF10	Register	System Rated Voltage	4014h	32 bit	#03	#16
MF11	Register	NGR Maximum Voltage	4016h	32 bit	#03	#16
MF12	Register	NGR Minimum Voltage	4018h	32 bit	#03	#16
MF13	Register	NGR Maximum Current	401Ah	32 bit	#03	#16
MF14	Register	NGR Minimum Current	401Ch	32 bit	#03	#16
MF15	Register	System Charging Current	401Eh	32 bit	#03	NR
MF16	Register	Alarm Value - Current or Voltage	4020h	32 bit	#03	NR

Note: *NA: not applicable*
NR: not recommended - could cause failure of the controller or data corruption.
XXXXh: "h" subscript in addresses indicates the address is hexadecimal.
Modification of variable not listed in this section could cause failure of the controller or data corruption.

To access the variables listed above, the controller responds to the following Modbus command numbers:

Table AG Modbus Command Numbers	
#01	Read Coils
#03	Read Holding Registers
#15	Force Coils
#16	Preset Holding Registers

Memory Float (MF) and long integer (ML) variables are a special case. Standard Modbus deals with 16 bit registers in transferring register data. The MF and ML variables are 32 bit double registers; the first 16-bit word is high for all 32-bit data types. For these variables, the Preset: Vector Length parameter must be doubled. For example, if it is decided to read all MF variables at one time, the Preset: Vector Length parameter should be 34. This parameter will always be an even number for MF and ML variables.

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Communication Manual with Modbus Memory Map

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