Mx7x

Modbus for Bitronics 70 Series

Manual

Mx7x

Modbus for Bitronics 70 Series

Publication Reference: Mx7xM/EN/M/E

GRID

CONTENTS

70 SERIES FIRMWARE VERSION

The following table provides the most recent firmware and software versions. For best results, the Configurator version used should match with the firmware version. A complete list of firmware and software versions is provided on the 70 Series Utilities CD.

Firmware Versions						
Description	Bios Version	DSP Firmware	Host Firmware	Configurator	Utilities CD	Release Date
M870 Family						
Mx7x Product Release, New Hardware supported Dual Bus, Analog I/O	2.1/3.0*	1.210	2.050	2.31	2.43	03/24/06
Mx7x Updated Release	2.1/3.0*	"	2.060	2.32	2.44	04/14/06
Mx7x Updated Release	2.1/3.0*	1.240	2.120	2.39	2.50	10/01/06
M87x Updated Release	2.1/3.0*	1.240	2.150	2.41	2.52	12/18/06
M87x Product Release, Fault Location, Adjustable Sample Rate	3.40	1.30	2.170	2.43	2.56	12/21/07
M87x Product Release; Add Demand per phase for Watts ,VAr, & VA. Configurator & Biview improvements w/ modems. Change to Digital I/O default watchdog contact (Configurator setup; not firmware dependent). Support new version of hardware on P3x, P4x modules.	3.40	1.30	2.18	3.00A	2.57	10/17/08
M87x Product Release: Added 1mHz accuracy on M87x. Improved poll rate from 500ms to 100ms for a single P40 transducer inputs module (M87x). Fault distance configuration is changed. Time sync with respect to DNP master is changed from the DNP master jamming the time to asking the master what time to jam. Increased waveform recording limit from 999 post trigger for longer recording.	3.40	1.31	2.19	3.02	2.58	09/30/09
M87x Product Release, IEC61850 & SNTP; Avg 3-Ph Amps and Avg 3-Ph Volts	3.40	1.30	3.01.0	3.01	3.01	1/30/09

Firmware Versions						
Description	**Bios Version**	**DSP Firmware**	**Host Firmware**	**Configurator**	**Utilities CD**	**Release Date**
M87x Product Release: Added 1mHz accuracy on M87x. Improved poll rate from 500ms to 100ms for a single P40 transducer inputs module (M87x). Fault distance configuration is changed. Time sync with respect to DNP master is changed from the DNP master jamming the time to asking the master what time to jam. Increased waveform recording limit from 999 post trigger for longer recording.	3.40	1.31	3.02	3.02	3.02	09/30/09

* H10/H11

70 SERIES MANUAL SET

M87x User Manual

M57x User Manual

70 SERIES Modbus Protocol

70 SERIES DNP3 Protocol

M870D Remote Display Manual

M570Dx Remote Display Manual

70 SERIES IEC 61850® Protocol Manual

CERTIFICATION

Alstom Grid certifies that the calibration of our products is based on measurements using equipment whose calibration is traceable to the United States National Institute of Standards Technology (NIST).

INSTALLATION AND MAINTENANCE

Alstom Grid products are designed for ease of installation and maintenance. As with any product of this nature, installation and maintenance can present electrical hazards and should be performed only by properly trained and qualified personnel. If the equipment is used in a manner not specified by Alstom Grid, the protection provided by the equipment may be impaired.

ASSISTANCE

For assistance, contact the Alstom Grid Worldwide Contact Centre:

http://www.alstom.com/grid/contactcentre/

Tel: +44 (0) 1785 250 070

SAFETY SECTION

Please refer to the M87x and M57x User Manuals for information regarding safety, installation, commissioning and decommissioning.

TRADEMARKS

The following are trademarks or registered trademarks of Alstom Grid:

Alstom Grid   the Alstom Grid logo

The following are trademarks or registered trademarks of Bitronics LLC:

The Bitronics logo   Bitronics

The following are trademarks or registered trademarks of the DNP User's Group:

DNP   DNP3

The following are trademarks or registered trademarks of the Electric Power Research Institute (EPRI):

UCA

The following are trademarks or registered trademarks of Schneider Automation, Inc.:

MODSOFT   Modicon   Modbus Plus   Modbus   Compact 984 PLC

The following are trademarks or registered trademarks of VentureCom, Inc.:

Phar Lap   the Phar Lap logo

The following are trademarks or registered trademarks of Systems Integration Specialists Company, Inc. (SISCO):

SISCO   MMS-EASE Lite   AX-S4MMS

The following are trademarks or registered trademarks of General Software, Inc.:

General Software   the GS logo   EMBEDDED BIOS   Embedded DOS

The following are trademarks or registered trademarks of the PCI Industrial Computer Manufacturers Group:

CompactPCI   PICMG the CompactPCI logo   the PICMG logo

1. MODBUS INTERFACE

1.1 Description

The 70 Series IEDs support the Modbus protocol on two or three of the serial ports (P2 and P3 for M57x, P2-P4 on M87x). These ports can be configured for RS232 or RS485. All of these ports can be used simultaneously. Refer to the M87x or M57x User Manuals for hardware details.

The Modbus network is a "MASTER" to "SLAVE" network, that is to say, one node asks a question and a second node answers. A NODE is a Modbus device (PLC, Computer, M871, etc.) that is connected to the network. Each SLAVE NODE has an ADDRESS in the range of 1 to 247; it is this address that allows a MASTER to selectively request data from any other device. Address 0 is a BROADCAST ADDRESS that can be used with certain MODBUS functions to allow the MASTER to address all SLAVE NODES at one time. The 70 Series IEDs do not respond to BROADCAST messages.

The Modbus implementation in the 70 Series IEDs conforms to all standard Modbus specifications and capabilities, such as maximum nodes, distance, signal sensitivity, etc. The 70 Series IEDs are classified as SLAVE DEVICES in the Modbus structure. The data items that are available from the instrument can be obtained via the Modbus Network by issuing a READ HOLDING REGISTERS command from the requesting node.

1.2 Modbus Address

Ports 2 & 3 in the M57x or 2, 3, and 4 in the M87x can be set up to be RS-232 or RS-485 (P1 is RS-232 only, and does not support Modbus), and support baud rates up to 38400. Setting the address and configuring the Serial Ports can be accomplished by running the 70 Series Configurator. The default configuration for the serial ports is:

Serial Port Default Settings					
Port	Protocol	Parity	Baud	IED Address	Physical Media
P1	Zmodem/Display/Log	None	9600		RS-232
P2	DNP 3.0	None	9600	1	RS-232
P3	Modbus	Even	9600	1	RS-232
P4	Zmodem/Display/Log	None	9600		RS-232

1.3 Transaction Timing

The instrument completes a set of calculations approximately every cycle (16.67ms @60Hz) and calculations for volt and amp measurements every quarter cycle (4.167ms @60Hz). The HOST CPU processor services the Modbus ports by interrupts received from the corresponding serial ports. Incoming messages are parsed and responded to in approximately 2 ms.

1.4 Data Format

The 70 Series IEDs contain a set of holding registers (4XXXX) into which the instrument places values that correspond to the measurements the instrument is making. These holding registers can be read by any other device on the network using a READ HOLDING REGISTER (Function Code 3).

When using HOLDING REGISTER DATA, the Health Check Register should always be read and checked before interpreting data, since some failure modes will cause erroneous data to be presented (See Section 1.8). For conversion of the register data into ENGINEERING UNITS, please refer to Section 1.6. For specifics concerning the correct command and its implementation, users are directed to the M87x and M57x User Manuals for the specific device that will request the data. Listed in section 1.4.1 are the register assignments for the 70 SERIES IEDs when using the Configurable or Single Feeder Configurable (SFC) selection (used for M571 and M871). NOTE: The 70 Series IEDs have a total of up to 6 different register sets (depending upon Configurator and firmware versions). A summary of the assignments for each of these six register sets is provided in Appendix A. Please refer to the 70 Series Configurator Modbus Register tab and click on the various options in the “Register Set” section to see register assignment details. For Configurator versions 2.27 or higher, the Register Sets on the left side of the box in the Modbus Register Screen are all fixed sets whereas the ones on the right side of the box are all configurable to varying degrees (some have a fixed portion followed by a section where the user can select any of the measurements available in the 70 Series IEDs). Note also that unless otherwise specified, all points are READ ONLY.

1.4.1 70 Series IEDs Modbus Register Assignments (Configurable/SFC (Single Feeder Configurable))

70 Series IEDs Modbus Register Assignments													
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
3	40001		Health 0	T1		Bit-0	DSP Gain Cal Error	Data	0-Norm	1-Fail	1	
						Bit-1	DSP Offset Cal Error					
						Bit-2	SIM Gain Cal Error					
						Bit-3	SIM Offset Cal Error					
						Bit-4	SIM Phase Cal error					
						Bit-5	SIM Ratio Csum Error					
						Bit-6	User Ratio Csum Error					
						Bit-7	User Gain Csum Error					
						Bit-8	User Phase Csum Error					
						Bit-9	DSP Board ID Csum Error					
						Bit-10	SIM Board ID Csum Error					
						Bit-11	User TDD Csum Error					
						Bit-12	DSP Integrity Csum Error					
						Bit-13	DSP Stack Overflow					
						Bit-14	CT\VT Scaling Error					
						Bit-15	Protocol Config Error					
3	40002		Health 1	T1		Bit-0	Reserved	Data	0-Norm	1-Fail	1	
						Bit-1	Reserved					
						Bit-2	Reserved					
						Bit-3	Reserved					
						Bit-4	Reserved					
						Bit-5	Reserved					
						Bit-6	Reserved					
						Bit-7	Reserved					

70 Series IEDs Modbus Register Assignments												
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
						Bit-8	Reserved					
						Bit-9	Reserved					
						Bit-10	Reserved					
						Bit-11	Reserved					
						Bit-12	Reserved					
						Bit-13	Reserved					
						Bit-14	Reserved					
						Bit-15	Reserved					
3	40003		Amps A	T2	Amp Scale			Data	0	32767	((1/32768) *10*Amp Scale) A	
3	40004		Amps B	T2	Amp Scale			Data	0	32767	((1/32768) *10*Amp Scale) A	
3	40005		Amps C	T2	Amp Scale			Data	0	32767	((1/32768) *10*Amp Scale) A	
3	40006		Amps N	T3	Amp Scale			Data	0	32767	((1/32768) *15*Amp Scale) A	
3	40007		Amps Residual	T3	Amp Scale			Data	0	32767	((1/32768) *15*Amp Scale) A	
3	40008		Volts A	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40009		Volts B	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40010		Volts C	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40011		Volts N	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40012		Volts AB	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40013		Volts BC	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40014		Volts CA	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40015		Volts A Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40016		Volts B Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40017		Volts C Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40018		Volts N Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40019		Volts AB Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	

70 Series IEDs Modbus Register Assignments												
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
3	40020		Volts BC Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40021		Volts CA Bus2	T4	Volt Scale			Data	0	32767	((1/32768) *150*Volt Scale) V	
3	40022		Watts A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) W	
3	40023		Watts B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) W	
3	40024		Watts C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) W	
3	40025		Watts Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *4500*Amp Scale * Volt Scale) W	
3	40026		VARs A	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) vars	
3	40027		VARs B	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) vars	
3	40028		VARs C	T5	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *1500*Amp Scale * Volt Scale) vars	
3	40029		VARs Total	T6	Amp Scale * Volt Scale			Data	-32768	32767	((1/32768) *4500*Amp Scale * Volt Scale) vars	
3	40030		VAs A	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *1500*Amp Scale * Volt Scale) VAs	
3	40031		VAs B	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *1500*Amp Scale * Volt Scale) VAs	
3	40032		VAs C	T5	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *1500*Amp Scale * Volt Scale) VAs	
3	40033		VAs Total Geometric	T6	Amp Scale * Volt Scale			Data	0	32767	((1/32768) *4500*Amp Scale * Volt Scale) VAs	
3	40034		Power Factor A	T7				Data	-1000	1000	0.001	
3	40035		Power Factor B	T7				Data	-1000	1000	0.001	
3	40036		Power Factor C	T7				Data	-1000	1000	0.001	
3	40037		Power Factor Total Geometric	T7				Data	-1000	1000	0.001	

70 Series IEDs Modbus Register Assignments												
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
3	40038		Frequency Volts A	T8				Data	2000	8000	0.01 Hz	
3	40039		Frequency Volts B	T8				Data	2000	8000	0.01 Hz	
3	40040		Frequency Volts C	T8				Data	2000	8000	0.01 Hz	
3	40041		Frequency Volts A Bus2	T8				Data	2000	8000	0.01 Hz	
3	40042		Frequency Volts B Bus2	T8				Data	2000	8000	0.01 Hz	
3	40043		Frequency Volts C Bus2	T8				Data	2000	8000	0.01 Hz	
3	40044		System Frequency	T8				Data	2000	8000	0.01 Hz	
3	40045		Phase Angle Volts A Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
3	40046		Phase Angle Volts B Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
3	40047		Phase Angle Volts C Bus1-Bus2	T9				Data	-1800	1800	0.1 Degrees	
3	40048		Phase Angle Amps A Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
3	40049		Phase Angle Amps B Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
3	40050		Phase Angle Amps C Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
3	40051		Phase Angle Volts A Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
3	40052		Phase Angle Volts B Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
3	40053		Phase Angle Volts C Harmonic 1	T9				Data	-1800	1800	0.1 Degrees	
3,6,16	40054		VA/PF Calc. Type	T1		1	Arithmetic	Setting	1	4	1	
						2	Geometric					
						3	3 Element (L-N)					
						4	2 Element (L-L)					
3	40055		Meter Type	T1		402	70 Series Register Set	Data	402	400	0	
3,6,16	40056		Volt Scale Factor	T10				Setting	1000	9999	1	
3,6,16	40057		Volt Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40058		Amp Scale Factor	T10				Setting	1000	9999	1	

70 Series IEDs Modbus Register Assignments												
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
3,6,16	40059		Amp Scale Factor Divisor	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40060		Xfmr Ratio Volts A	T10				Setting	1000	9999	1	
3,6,16	40061		Xfmr Ratio Divisor Volts A	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40062		Xfmr Ratio Volts B	T10				Setting	1000	9999	1	
3,6,16	40063		Xfmr Ratio Divisor Volts B	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40064		Xfmr Ratio Volts C	T10				Setting	1000	9999	1	
3,6,16	40065		Xfmr Ratio Divisor Volts C	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40066		Xfmr Ratio Volts N	T10				Setting	1000	9999	1	
3,6,16	40067		Xfmr Ratio Divisor Volts N	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40068		Xfmr Ratio Volts A Bus2	T10				Setting	1000	9999	1	
3,6,16	40069		Xfmr Ratio Divisor Volts A Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40070		Xfmr Ratio Volts B Bus2	T10				Setting	1000	9999	1	
3,6,16	40071		Xfmr Ratio Divisor Volts B Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40072		Xfmr Ratio Volts C Bus2	T10				Setting	1000	9999	1	
3,6,16	40073		Xfmr Ratio Divisor Volts C Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40074		Xfmr Ratio Volts N Bus2	T10				Setting	1000	9999	1	
3,6,16	40075		Xfmr Ratio Divisor Volts N Bus2	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40076		Xfmr Ratio Amps A	T10				Setting	1000	9999	1	
3,6,16	40077		Xfmr Ratio Divisor Amps A	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	

70 Series IEDs Modbus Register Assignments												
Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
3,6,16	40078		Xfmr Ratio Amps B	T10				Setting	1000	9999	1	
3,6,16	40079		Xfmr Ratio Divisor Amps B	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40080		Xfmr Ratio Amps C	T10				Setting	1000	9999	1	
3,6,16	40081		Xfmr Ratio Divisor Amps C	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40082		Xfmr Ratio Amps N	T10				Setting	1000	9999	1	
3,6,16	40083		Xfmr Ratio Divisor Amps N	T11				Setting	1	1000	Multiply by 10 (valid values are 1,10,100,1000)	
3,6,16	40084		User Gain Volts A	T12				Setting	-32768	32767	1/16384	
3,6,16	40085		User Gain Volts B	T12				Setting	-32768	32767	1/16384	
3,6,16	40086		User Gain Volts C	T12				Setting	-32768	32767	1/16384	
3,6,16	40087		User Gain Volts N	T12				Setting	-32768	32767	1/16384	
3,6,16	40088		User Gain Volts A Bus2	T12				Setting	-32768	32767	1/16384	
3,6,16	40089		User Gain Volts B Bus2	T12				Setting	-32768	32767	1/16384	
3,6,16	40090		User Gain Volts C Bus2	T12				Setting	-32768	32767	1/16384	
3,6,16	40091		User Gain Volts N Bus2	T12				Setting	-32768	32767	1/16384	
3,6,16	40092		User Gain Amps A	T12				Setting	-32768	32767	1/16384	
3,6,16	40093		User Gain Amps B	T12				Setting	-32768	32767	1/16384	
3,6,16	40094		User Gain Amps C	T12				Setting	-32768	32767	1/16384	
3,6,16	40095		User Gain Amps N	T12				Setting	-32768	32767	1/16384	
3,6,16	40096		User Phase Correction Volts A	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40097		User Phase Correction Volts B	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40098		User Phase Correction Volts C	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40099		User Phase Correction Volts N	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40100		User Phase Correction Volts A Bus2	T8				Setting	-18000	18000	0.01 Degrees	

70 Series IEDs Modbus Register Assignments

Code	Modbus Address		Contents	Data	Scale	Ind	Values/Dependencies	Type	Min	Max	Step	Pass
3,6,16	40101		User Phase Correction Volts B Bus2	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40102		User Phase Correction Volts C Bus2	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40103		User Phase Correction Volts N Bus2	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40104		User Phase Correction Amps A	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40105		User Phase Correction Amps B	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40106		User Phase Correction Amps C	T8				Setting	-18000	18000	0.01 Degrees	
3,6,16	40107		User Phase Correction Amps N	T8				Setting	-18000	18000	0.01 Degrees	

1.4.2 Modbus Calculation-Type Codes

Type	Value / Bit Mask	Description
T1		Unsigned 16-Bit Integer
T2		Signed 16-Bit Integer - 2's Complement - Saturation 10
		Float Value = ((Integer Value) / 32768) * Scale * 10)
		Example: 5.0 A stored as 16384 when Amp Scale = 1:1
T3		Signed 16-Bit Integer - 2's Complement - Saturation 15
		Float Value = ((Integer Value) / 32768) * Scale * 15)
		Example: 150 A stored as 16384 when Amp Scale = 20:1
T4		Signed 16-Bit Integer - 2's Complement - Saturation 150
		Float Value = ((Integer Value) / 32768) * Scale * 150)
		Example: 119.998 V stored as 26214 when Volt Scale = 1:1
T5		Signed 16-Bit Integer - 2's Complement - Saturation 1500
		Float Value = ((Integer Value) / 32768) * Scale * 1500)
		Example: -750.0 W stored as -16384 when Volt Scale = 1:1, Amp Scale 1:1
T6		Signed 16-Bit Integer - 2's Complement - Saturation 4500
		Float Value = ((Integer Value) / 32768) * Scale * 4500)
		Example: -90.0 kW stored as -8192 when Volt Scale = 20:1, Amp Scale 4:1
T7		Signed 16-Bit Integer - 2's Complement - 3 Decimal Places
		Example: -12.345 stored as -12345
T8		Signed 16-Bit Integer - 2's Complement - 2 Decimal Places
		Example: 123.45 stored as 12345
T9		Signed 16-Bit Integer - 2's Complement -1 Decimal Place
		Example: -1234.5 stored as -12345
T10		Unsigned 16-Bit Integer - Normalized Ratio
		ratio = (Normalized Ratio / Ratio Divisor)
		Example : 1.234, 12.34, 123.4, and 1234 are all stored as 1234
T11		Unsigned 16-Bit Integer - Ratio Divisor
		ratio = (Normalized Ratio / Ratio Divisor); valid Ratio Divisors are 1,10,100,1000
		Example: X.XXX stored as 1000, XX.XX stored as 100, XXX.X stored as 10
T12		Signed 16-Bit - 2's Complement - Saturation 2
		Gain Value = Integer Value /16384)
		Example: -0.250 stored as -4096

Type	Value / Bit Mask	Description
T13		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 10
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 10
		Example: 5.0 A stored as 3071 when Amp Scale 1:1
T14		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 150
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 150
		Example: 119.97 V stored as 3685 when Volt Scale 1:1
T15		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 1000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 1000
		Example: -500 W stored as 1023 when Volt Scale = 1:1, Amp Scale = 1:1
T16		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 3000
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 3000
		Example: 349.10 kW stored as 3040 when Volt Scale = 6:1, Amp Scale = 40:1
T17		Unsigned 16-Bit Integer - 12 Bit Offset Binary - Saturation 15
		Float Value =((Integer Value - 2047) / (2048)) * Scale * 15
		Example: 11.79 A stored as 2369 when Amp Scale 5:1
T18		Unsigned 16-Bit Integer - 12 Bit Offset Binary -1 Decimal Place
		Float Value = ((Integer Value - 2047) / (10))
		Example: 121.4 degrees stored as 3261
T19		Unsigned 16-Bit Integer - 12 Bit Offset Binary -3 Decimal Place
		Float Value = ((Integer Value - 2047) / (1000))
		Example: 0.978 Power Factor stored as 3025
T20		Unsigned 16-Bit Integer - Bit Control/Status
		0' - stored as zero; '1' - stored as 65536
T21		Unsigned 16-Bit Integer - 3 Decimal Places
		Example: 54.321 stored as 54321
T22		Bit
		Example: 1-bit is set, 0-bit is clear

1.5 Configuration

1.5.1 Setting CT and VT Ratios

The 70 Series IEDs are capable of internally storing and recalling CT and VT ratios. The CT and VT ratios are written to registers 40060 through 40083 over the Modbus communication port, and are stored in non-volatile memory on the CT/VT Module. Each ratio is stored in two registers, one for the Normalized Ratio and the other for the Ratio Divisor. Allowable constants for the normalized ratios are 1000 to 9999. The Ratio Divisors may be 1, 10, 100, or 1000 only. The number stored will be the high side rating of the CT Ratio or VT Ratio. Both a 500:5 ratio CT and a 100:1 CT will have a value of 100 stored. For example, to calculate a CT and VT ratio for Phase A from the data stored in the M871, use the following equation:

$$Phase\ A\ CT_{RATIO} = \frac{Phase\ A\ CT\ Value\,(40076)}{Phase\ A\ CT\ \ Ratio\,Divisor\ (40077)}$$

$$Phase\ A\ PT_{RATIO} = \frac{Phase\ A\ PT\ Value\,(40060)}{Phase\ A\ PT\ \ Ratio\,Divisor\ (40061)}$$

The 70 Series IEDs calculate all measured quantities in **PRIMARY UNITS**. The CT and VT ratio information (registers 40060 through 40083) is used to calculate these primary values. To force the 70 Series IED to report in secondary units, set the Scale Factor = to the CT or VT ratio, as appropriate.

NOTE: The Full Scale Integer Value of current and voltage reported by the 70 Series IEDs over Modbus can be changed, see Section 1.5.2.

In the event of a CT/VT Ratio Checksum Failure, the value in the Normalized CT Ratio and Normalized VT Ratio registers default to 1000, and the value in the CT Ratio Divisor and VT Ratio Divisor default to 1000. This results in a 1:1 CT Ratio and 1:1 VT Ratio.

WARNING – TO PRESERVE SYSTEM PERFORMANCE, ONLY WRITE TO RATIO REGISTERS WHEN THE RATIOS NEED TO BE CHANGED.

1.5.2 Setting Current and Voltage Scale Factors

As detailed in Section 1.6, the data in the 70 Series IED Modbus registers is in NORMALIZED 2'S COMPLEMENT format. Measurements presented in this format do not have as much resolution as the 70 Series IED internal floating register values. Because of the wide dynamic range of the 70 Series IED inputs, the default full-scale integer representation of measurement values is a compromise that has been selected to accommodate typical system signal levels, while giving reasonable resolution. The maximum (or full scale) integer value that can be reported corresponds to some particular level of Amperes, Volts, Watts, etc.

The maximum full scale integer value of Amperes and Volts in the NORMALIZED 2'S COMPLEMENT format can be changed by means of the Current Scale Factor and Voltage Scale Factor ($I_{SCALE\ FACTOR}$ and $V_{SCALE\ FACTOR}$), which are modified by writing to the Normalized Scale Factor and Scale Factor Divisor (40056 to 40059) registers. *These Current Scale Factor and Voltage Scale Factor values are multipliers of the Default Full Scale values.* To convert values reported in Modbus registers to engineering units, refer to Section 1.6.

The default full-scale values for quantities are:

Quantity	Default Full Scale
Phase Current	10
Neutral Current	15
Voltages	150
Per-Phase Power (Watt, VAR, VA)	1500
Total Power (Watt, VAR, VA)	4500

$$I_{SCALE\ FACTOR} = \frac{Normalized\ Current\ Scale\ Factor\ (40058)}{Current\ Scale\ Factor\ Divisor\ (40059)}$$

$$V_{SCALE\ FACTOR} = \frac{Normalized\ Voltage\ Scale\ Factor\ (40056)}{Voltage\ Scale\ Factor\ Divisor\ (40057)}$$

The Current and Voltage Scale Factors are written to registers 40056 through 40059 and are stored in non-volatile memory on the 70 SERIES IED's Host CPU Board. Each Scale Factor is stored in two registers, one for the Normalized Scale Factor, and the other for the Scale Factor Divisor. Allowable constants for Normalized Scale Factors are 1000 to 9999. The Scale Factor Divisors may be 1, 10, 100, or 1000 only.

1.5.2.1 Scale Factor Voltage Measurement Example

For example, the default full-scale value of voltage (registers 40008 to 40021) is 150V, the default value of the Normalized Voltage Scale Factor (40056) is 1000, and the default value of the Voltage Scale Factor Divisor (40057) is 1000. Assume a system with a 1:1 VT Ratio. If it is desired to change the full-scale representation of volts to 300V (to accommodate a 208V input, for instance), change the value of the Normalized Voltage Scale Factor (40056) to 2000.

$$VOLTAGE\ Phase\ A-B = \frac{Value}{32768} \times 150 \times \frac{2000}{1000} = 300V$$

Note that since $V_{SCALE\ FACTOR}$ = 2, the values represented by the power quantity registers will also be doubled.

Note that the full-scale representation of all the Voltage measurements will also change. The scaling for Power quantities cannot be set independently and will be the product of the Voltage and Current Scale Factors.

1.5.2.2 Scale Factor Current Measurement Example

Consider a system with a 2000:5 (400:1) CT, on which it is desired to measure the Phase A amperes. The Normalized CT Ratio (40060) would be set to 4000, the CT Ratio Divisor (40061) to 10. With the default settings for the Current Scale Factor, the maximum register value of "32767" would yield:

$$AMPEREs\ Phase\ A = \frac{Value(=32767)}{32768} \times 10 \times \frac{1000}{1000} = 10A$$

In other words, the integer value for Amperes would be at a maximum with only 10A flowing through the system primary conductors. To compensate for this, set the $I_{SCALE\ FACTOR}$ equal to the CT_{RATIO}. The Normalized Current Scale Factor (40058) would be set to 4000, and the Current Scale Factor Divisor (40059) to 10. If the maximum value of "32767" is returned in register 40003, it is converted to Amperes as follows:

$$AMPEREs\ Phase\ A = \frac{Value}{32768} \times 10 \times I_{SCALE\ FACTOR} = \frac{32767}{32768} \times 10 \times \frac{4000}{10} = 4000A$$

If it is known that the maximum current on the circuit is not this high, and it is desired to set the full scale representation to 1200A for added resolution, the Normalized Current Scale Factor (40058) could be set to 1200, and the Current Scale Factor Divisor (40059) to 10. The maximum value returned (32767) would then be equal to:

$$AMPEREs Phase A = \frac{Value(=32767)}{32768} \times 10 \times \frac{1200}{10} = 1200A$$

1.5.3 Resetting Energy and Demands and Triggering Recorders

The Energy and Demand registers can be RESET by writing a non-zero value to the appropriate Holding Registers. Writing a non-zero value to the Recorder Registers will trigger a waveform or disturbance record. All of these registers are user-defined, that is they are not part of the default 70 Series IED register set.

Reset / Trigger Functions
Reset Energy
Reset Demand Amps
Reset Demand Volts
Reset Demand Power
Reset Demand Harmonic
Trigger Waveform Recorder
Trigger Disturbance Recorder 1
Trigger Disturbance Recorder 2

1.5.4 Tag Register

The 70 Series IEDs provide a "TAG" register for user identification purposes. This register is a READ/WRITE register that allows the user to write a number from 1 to 65,535 in the tag register.

1.5.5 VA Calculation Type Register

The 70 Series IED can be configured to use one of several different methods to calculate Total VAs. Refer to the M87x User Manual for an explanation of the different calculation types. The VA Calculation Type register (40054) is a READ/WRITE register.

VA Calculation Type	Register Value
Arithmetic	1
Geometric	2
Equivalent 3-element (WYE)	3
Equivalent 2-element (DELTA)	4

1.6 Converting Data to Engineering Units

As was mentioned in Section 1.5, the majority of the data is stored in a Normalized 2's Complement format. When displaying these values at another location, it may be desirable to convert this format into engineering units. This conversion is readily accomplished using the following simple scaling equations:

BASIC EQUATION FOR NORMALIZED ANALOG INPUTS:

$$Engineering\,Units = \frac{Value}{32768} \times Default\ Full\ Scale_{SECONDARY} \times \frac{Normalized\ Scale\ Factor}{Scale\ Factor\ Divisor}$$

The **Value** referred to in the equations would be the value stored in the register that you wished to convert to engineering units. For example if you wanted to convert Phase A Amperes into engineering units, Value would be the value in 40003.

ENERGY is stored as 32-BIT values in static COUNTER registers. Energy values are in units of PRIMARY kWh or kVARh.

FREQUENCY is stored as a single binary value that is the actual frequency times 100.

POWER FACTOR is stored as the value times 1000. Negative power factors indicate that the VARs are positive. The sign of the Power Factor is the inversion of the Exclusive-OR of the Watts and VARs (i.e. if either the Watts or VARs are negative, then the Power Factor will be negative).

EQUATIONS FOR FIXED DATA REGISTER SET:

$$I_{SCALE\ FACTOR} = \frac{Normalized\ Current\ Scale\ Factor\ (40058)}{Current\ Scale\ Factor\ Divisor\ (40059)}$$

$$V_{SCALE\ FACTOR} = \frac{Normalized\ Voltage\ Scale\ Factor\ (40046)}{Voltage\ Scale\ Factor\ Divisor\ (40057)}$$

$$AMPEREs_{(Inst,\ Demand,\ Max)} = \frac{Value}{32768} \times 10 \times I_{SCALE\ FACTOR}$$

$$AMPEREs_{N\ (Inst,\ Demand,\ Max)} = \frac{Value}{32768} \times 15 \times I_{SCALE\ FACTOR}$$

$$VOLTs_{(Inst,\ Demand,\ Min,\ Max)} = \frac{Value}{32768} \times 150 \times V_{SCALE\ FACTOR}$$

$$WATTs(VARs)\,(VAs)_{TOTAL\,(Inst,\ Demand,\ Max,\ Max)} = \frac{Value}{32768} \times 4500 \times V_{SCALE\ FACTOR} \times I_{SCALE\ FACTOR}$$

$$WATTs(VARs)\,(VAs)_{PER\ PHASE\,(Inst)} = \frac{Value}{32768} \times 1500 \times V_{SCALE\ FACTOR} \times I_{SCALE\ FACTOR}$$

$$kWh\,(kVARh) = \left[Value_{HIGH\ WORD} \times 65536\right] + Value_{LOW\ WORD}$$

$$FREQUENCY = \frac{Value}{100}$$

$$PF = \frac{Value}{1000}\ (-Lag, +Lead)$$

$$PHASE\ DIFFERENCE = \frac{Value}{10}\ (+Line\ Leading\ \mathrm{Ref})$$

All quantities reported in Primary Values. To force the 70 Series IED to report in secondary units, set the Scale Factor = to the CT or VT ratio, as appropriate.

The above equations provide answers in fundamental units (VOLTs, AMPs, WATTs, VARs, VAs and Hz). If the user desires other units such as KILOVOLTS, KILOWATTS or KILOVARS, the answers given by the equations should be divided by 1,000. If the user desires MEGAWATTS or MEGAVARS, the answers given by the equations should be divided by 1,000,000. Energy values are in units of kWh or kVARh.

1.7 Register Sets and Register Types

The 70 Series IEDs are shipped with a pre-defined set of registers and data types. These fixed registers do not change, but may be augmented by adding additional registers (and their data type) from the master listing. The List of Available Measurements may be found in the M87x User Manual. The 70 Series Configurator is required to modify the registers.

1.7.1 Time Sync

Pre-defined data points for status are used to indicate the current state for each of the various time synchronization methods possible on the 70 Series IEDs. These data points appear in the Bitronics Advanced Fixed (BAF) and Harmonic Advance Fixed (HAF) point sets. The 70 Series Configurator allows the user to modify the configuration of time sync parameters.

The following time sync points will return status values of ‘0’ if a time sync master is inactive and ‘1’ if a time sync master is active:

IRIG-B Time Sync, (UCA) Network Time Sync, SNTP Time Sync, DNP Time Sync.

1.7.2 Best Clock Source

The M87x or M57x determines the ‘Best Clock Source’ and returns a value to indicate the master that is synchronizing the time. This is based upon which time sync masters are active as determined from the Time Sync Data Points and which time sync master takes priority.

Best Clock source	Value
IRIG-B:	**2**
(UCA) Network Time Sync	**3**
SNTP	**4**
DNP	**5**
Manual time set	**0**

Refer to the IED User Manuals (M87x or M57x) for additional information on Time Sync clock source priority.

1.8 Health Check

The 70 Series IED has several self-tests built in to ensure that the instrument is performing accurately. The results of these self-tests are available in the Health Check register (40001), which is a simple 16-bit binary value. Each bit represents the results of a particular self-test, with "0" indicating the test was passed, and "1" indicating the test was failed. The definitions of the various self-tests are described in the M87x or M57x User Manuals. The following table lists possible faults that would be detected by the self-tests, how the fault is indicated, the effects of the fault and any necessary corrective actions.

Self Test Bits				
Bit #	Description	Hardware	Effect	Default Value
0(LSB)	Factory gain calibration of Analog-Digital Signal Processor Module checksum error.	-A10 EEProm	Unit will continue to function using default values, at reduced accuracy.	A/D Gain = 1
1	Factory offset calibration of Analog-Digital Signal Processor Module checksum error.	-A10 EEProm	Unit will continue to function using default values, at reduced accuracy.	A/D Offset = 0
2	Factory gain calibration of Signal Input Module checksum error.	-S1x EEProm	Unit will continue to function using default values, at reduced accuracy.	CT/VT Gain = 1
3	Factory offset calibration of Signal Input Module checksum error.	-S1x EEProm	Unit will continue to function using default values, at reduced accuracy.	CT/VT Offset = 0
4	Factory phase calibration of Signal Input Module checksum error.	-S1x EEProm	Unit will continue to function using default values, at reduced accuracy.	CT/VT Phase = 0
5	Factory defined internal ratios of Signal Input Module checksum error. (Type of Signal Input Module)	-S1x EEProm	Unit will continue to function. Assumes -S10 Signal Input Module	Volts Ratio = 60 :1 Amps Ratio = 14.136 :1
6	User defined external transformer ratio checksum error.	-S1x EEProm	Unit will continue to function using default values (i.e. w/o user ratios).	User CT = 5:5, VT = 1:1
7	User gain correction values checksum error.	-S1x EEProm	Unit will continue to function using default values (i.e. w/o user gain).	User Gain = 1
8	User phase correction values checksum error.	-S1x EEProm	Unit will continue to function using default values (i.e. w/o user phase).	User Phase = 0
9	Factory defined board ID for Analog-Digital Signal Processor Module checksum error.	-A10 EEProm	Assumes default Analog-Digital Signal Processor Module.	Module -A10
10	Factory defined board ID for Signal Input Module checksum error.	-S1x EEProm	Assumes default Signal Input Module.	Module -S10
11	User defined denominators for TDD measurement checksum error.	-S1x EEProm	Assumes default TDD Denominator.	TDD Denom = 5A Secondary
12	DSP program integrity checksum error.	-A10 DSP Ram	Host trips watchdog, unit reboots.	
13	DSP stack overflow.	-A10 DSP Ram	Host trips watchdog, unit reboots.	
14	Invalid or missing Amp and/or Voltage Scale Factor	-H11 Flash File	Protocol will use default Scale Factor	Scale Factor = 1:1
15	Protocol configuration invalid	-H11 Flash File	M87x uses default protocol configuration	70 Series IED register set

1.9 Diagnostic Status LED

The Diagnostic LED is an indicator that shows the communications activity on the Modbus port on the 70 Series IED. The Diagnostic LED is a bi-colour LED (red/green) indicator that is located on the Front Panel Board adjacent to each serial port. The Diagnostic LED will flash red every time the 70 Series IED receives data via the associated port and will flash green whenever the 70 Series IED sends data over the associated serial port. If the LED does not flash RED when a message is sent to it from a MASTER, check the network for the following problems:

1. Cable open or short circuit
2. Defective termination
3. Incorrect MODBUS ADDRESS
4. Incorrect polarity of cable connections

1.10 Heartbeat State Counter

The 70 Series IED provides a Heartbeat State Counter Register that allows the user to determine the time between successive polls. This counter will increment by the number of milliseconds that have elapsed since the last time the data was updated. Another use of this register is as a visual indicator that the data is changing; it allows users of certain MMIs to identify disruption in the polling of the instrument. The Heartbeat State Counter is a full 16-bit counter that rolls over at 65535 (65.535 seconds). The counter starts at zero on power-up, and is NOT stored in non-volatile memory.

1.11 Meter ID Register

70 Series IEDs provide a "Meter Type ID" register for model identification purposes (40055 for M87x default register set). This register is pre-programmed at the factory to be either 404 in M87x devices, or 501 in M57x devices.

2. MODBUS PROTOCOL

2.1 Introduction

The MODBUS protocol is an open standard which defines a command-response method of communicating digital information between a master and slave device. The electrical connection between devices is known as a bus. In MODBUS, two types of devices attach to the bus, master and slave devices. A master device issues commands to slaves. A slave device, such as the 70 Series IED, issues responses to master commands that are addressed to them. Each bus must contain exactly one master and may contain as many slaves as the electrical standards permit.

All devices on a bus must operate according to the same electrical standards (i.e. all must be RS-232C or all must be RS-485). RS-232C standards specify that only two devices may be connected to a bus (i.e. only one slave is allowed). RS-485 specifications allow up to 32 devices (31 slaves) on a bus.

The MODBUS protocol specifications define two types of transmission modes: ASCII and RTU. This manual describes only the more common RTU mode. For more information, the manual "MODICON MODBUS PROTOCOL REFERENCE GUIDE" (PI-MBUS-300) may be purchased for a nominal fee directly from Modicon Inc.

2.2 MODBUS RTU Message Framing

Each message from either a master or slave consists of a continuous stream of characters. A silent interval of 3.5 character times (3.5 * 11 bits / 9600 baud = 3.5 millisecond), or more, separates these streams. 70 Series instruments implement this requirement by waiting for a 3.5 character time gap between characters. If the stream is valid and is addressed to this instrument, then the instrument responds as follows:

– Enable the output interface drivers (RS-485 option only)

– Wait TX Delay time (if configured)

– Send the response as a continuous stream

– Wait 3.5 character times

– Disable the output interface drivers (RS-485 option only)

2.3 MODBUS RTU Message Content

The MODBUS RTU message stream consists of an address byte, a function code byte, a number of message bytes, and two check bytes. The address byte, which is in the range 1... 247, specifies the identity of the slave device. The function code byte in a master command indicates the operation that the slave is to perform. The function code byte in a slave response is the same value as the master command function code if no error occurs, otherwise it has 128 added to it. The message bytes in a command contain additional information needed to perform the command. Message bytes in a response contain the data requested if no error has occurred or a one-byte exception code upon errors. The check bytes are generated using the CRC-16 polynomial generator sequence (x16 + x15 + x2 + 1) with the remainder pre-initialized to all 1's. The most significant byte of the CRC is transmitted first.

2.4 MODBUS Function Codes

70 Series instruments currently support the function codes shown in the following table. Note that the values are shown in hexadecimal (base 16). This table also shows the value that a slave would return upon an error.

MODBUS Function Codes			
Master Function Code	Slave Error Code	Name	Meaning
03_{16}	83_{16}	Read Holding Registers	Read values from transducer
06_{16}	86_{16}	Preset Single Register	Write ratio or reset energy/demand
10_{16}	90_{16}	Preset Multiple Registers	Write ratio or reset energy/demand

2.5 MODBUS Exception Codes

70 Series instruments return exception codes back to the master upon certain conditions. All functions codes greater then 127 decimal ($7F_{16}$ or 0x7F) indicate a slave error response. The message byte indicates the exception code according to the following table:

MODBUS Exception Codes		
Code	Name	Meaning
1	Illegal Function	Master command contained an unrecognized function code.
2	Illegal Data Address	Starting address is illegal. Note that some registers are read-only and some are read/write.
3	Illegal Data Value	Either the register count is invalid or an attempt to write an illegal register value was found. Note that this code can be caused by attempting to read beyond the last instrument register.
4	Slave Device Failure	Instrument has failed. If problem persists, please consult customer service.

2.6 Supported MODBUS Commands

70 Series instruments support one read and two write commands. All commands require a register address to be specified in the command. The first register, named 40001 is at hexadecimal address 0x0000. The energy/demand reset register, named 40100 is at hex address 0x0063. In commands and responses, the most significant byte of a two-byte value is transmitted first. All examples that follow use the hexadecimal values and an instrument address of 1.

2.6.1 Read Holding Registers (Function Code 03)

This function reads from 1 to 125 registers from the 70 Series instrument. The command requires a starting register and the number of registers to read. Attempting to read non-existent registers will cause an exception. Modbus read commands are limited to 125 registers maximum per read request, and some Modicon PLC Master Blocks (MSTR) are limited to 100 registers maximum per read request. The following example (M871 register set) shows two registers being read: Volts A (register 40008) and Volts B (40009).

COMMAND - Function Code 03 (Read Holding Registers)			
Byte	Name	Example	Notes
1	Slave Address	1	
2	Function code	3	
3	Start address high	0	Volts A at register 40008
4	Start address low	7	(40008-40001=07)
5	Register count high	0	
6	Register count low	2	Read 2 registers total
7	CRC-16 low	75	
8	CRC-16 high	CA	

RESPONSE - Function Code 03 (Read Holding Registers)			
Byte	Name	Example	Notes
1	Slave Address	1	
2	Function code	3	
3	Byte count	4	2 registers, 2 bytes each
4	Data high (40008)	66	Volts A = 6670 hex = 26224 decimal
5	Data low (40008)	70	
6	Data high (40009)	66	Volts B = 6650 hex = 26192 decimal
7	Data low (40009)	50	
8	CRC-16 low	CE	
9	CRC-16 high	FC	

2.6.2 Preset Single Register (Function Code 06)

This function writes to a single register. An attempt to write to a READ-ONLY register results in an exception response. The response to a valid (writeable) register command is an echo of the command. The following example shows setting of the VA calculation type (writing 2 to register 40054) command.

COMMAND and RESPONSE - Function Code 06 (Preset Single Register)			
Byte	Name	Example	Notes
1	Slave Address	1	
2	Function code	6	
3	Start address high	0	0035 hex = 53 decimal to specify register 40054
4	Start address low	53	
5	Data high	0	
6	Data low	02	0002 = 2 decimal
7	CRC-16 low	18	
8	CRC-16 high	05	

2.6.3 Preset Multiple Registers (Function Code 16)

This function writes one or more contiguous registers. An attempt to write to a READ-ONLY register results in an exception. The following example shows setting the Volt Scale Factor (40056) to 1000 and the Volt Scale Factor Divisor to 1000.

COMMAND - Function Code 16 (Preset Multiple Registers)			
Byte	Name	Example	Notes
1	Slave Address	1	
2	Function code	10	10 hex = 16 decimal
3	Start address high	0	0037 hex = 55 decimal to specify register 40056
4	Start address low	37	
5	Register count high	0	We write 2 registers (40056 and 40057)
6	Register count low	2	
7	Byte count	4	Two register, 4 bytes
8	Data high	3	Write 1000 to register 40056 : 03E8 = 1000 decimal
9	Data low	E8	
10	Data high	0	Write 100 to register 40057 : 0064 = 100 decimal
11	Data low	64	
12	CRC-16 low	30	
13	CRC-16 high	C6	

3. MODBUS OVER ETHERNET (TCP)

If the 70 Series IED is equipped with an Ethernet Module (refer to the M57x or M87x Operator's Manual), then it will respond to Modbus commands via TCP. The 70 Series IEDs can communicate with any device certified by Schneider Automation, Inc. for Modbus over Ethernet, as well as other devices. The 70 Series IED can simultaneously support Modbus, DNP3, and UCA2 protocols over the Ethernet link. The table below lists port assignments for all Ethernet based protocols supported by the 70 Series.

PROTOCOL	PORT NUMBER
DNP	20000 (TCP, UDP)
FTP (recommend passive mode)	20, 21 (TCP)
Modbus	502 (TCP)
MMS (UCA & 61850)	102 (TCP)
SMTP (electronic mail)	25 (TCP)
SNTP (network time synch)	123 (UDP)
Telnet	23 (TCP)

The Modbus/TCP interface allows up to 63 simultaneous connections to the 70 Series IED. There are no configuration parameters. A TCP keep-alive timer ensures that connections close 2 hours after loss of contact with the 70 Series IED (also known as a "backhoe disconnect"). Any Unit_Id (including zero) will be accepted since there is only one device per IP address.

3.1 IP Addressing

The TCP/IP stack needs to be configured with an IP address, a SUBNET mask, and a ROUTER (GATEWAY) address. It is very important that the network have no duplicate IP addresses. Configuration of the address may be accomplished by using UCA, by running the 70 Series Configurator, or via a front panel serial port using a terminal emulator such as HyperTerminal™ or ProComm™

The units are pre-configured with an IP address / subnet mask/gateway address of:

192.168.0.254 / 255.255.255.0 / 192.168.0.1

4. MODBUS FILE TRANSFER

At the time this document was issued, a Modbus file transfer standard did not exist. The transfer protocol implemented, implemented by Alstom utilizes five upper pages of the 40000 Series Holding Registers to accomplish the file transfer. The 70 Series IED writes blocks of data into these registers and the Modbus master reads the blocks out of these pages and reconstructs the file.

The 40000 Series Holding Register pages are defined as follows:

Address	Function	Contents
FA00 to FAFA	Read 24 word	Read Header
FB00 to FBFA	Read N words	Read N words of file parameters
FC00 to FCFA	Read N words	Read N words of file parameters again
FD00 to FDFA	Read N words	Read N words of file data
FE00 to FEFA	Read N words	Read N words of file data again

The transfer protocol provides for three types of data transfer: the file header, the file parameters, and the file data. The transfer protocol also provides a means to re-read the last block of the file parameters and file data in case an error occurred during the transfer. The file header only contains 24 words and is not refreshed with new data after it has been read. If an error occurs reading the file header, the file header can simply be re-read. The file parameter and file header blocks are refreshed with the next block of data after they are read. If an error occurs while reading a block of the file parameter or file data, the data can be re-read by requesting the repeat page for the respective data type.

4.1 Specifications

The file header format and the **70 Series IED's** header values are specified as follows:

Word	Parameter	70 Series IED Value
1	type of transfer	0
2-3	# bytes in parameter field	26
4-5	# bytes in data field	Size of file (in bytes) parameters again
7-8	product reference	Mx7x (4 ASCII bytes)
9	transmission product version	1
10-13	product serial number	00xxxxxx (8 ASCII bytes)
14	type of transfer (by product)	4 - .ZIP file (i.e. WVxxx.zip) 5 - Modbus file directory 6 - .DAT file (i.e. TR1.dat) 7 - .CFG file (i.e. TR1.cfg)
15-18	first element time tag	0 (format not supported)
19-24	reserved	0

The Alstom Modbus standard does not specify a set of file parameters. According to the specification, the set of file parameters is used to decode the transmitted file at the application level. The 70 Series IED parameters are as follows:

Word	Parameter	Description
1	File number	Each file is assigned a unique file number
2-7	File name	DOS style file name
8-9	File size	Size of file (in bytes) parameters again
10	File date	MSB - month (1-12) LSB – day (1-31)
11	File year	Year (xxxx)
12	File time	MSB – hour (1-24) LSB – minute (0-59)
13	File status	0 – previously downloaded 1 – not yet downloaded

Note that the File Status only reflects the download status of the file with respect to Modbus masters (not whether the file was downloaded by other masters such as DNP, Zmodem, FTP, or UCA).

4.2 Alstom Standard

The Alstom standard specifies that the file transfer work as follows:

1. Modbus masters poll Modbus IEDs via a Fast Reading Byte (Modbus 07-Read Exception Status) command to determine whether a file is available for downloading. If the IED has a file available (not yet downloaded), the IED sets the associated bit in the Fast Reading Byte response.
2. Modbus masters detect the bit in the Fast Reading Byte response and read the File Header (address 0xFA00) from the Modbus IED.
3. The Modbus master determines the parameter field size and file data size from the data returned in the File Header.
4. The Modbus master reads the parameter field by requesting the appropriate number of blocks and bytes from the File Parameter page (address 0xFB00) of the Modbus IED.
5. The Modbus master then reads the file by requesting the appropriate number of blocks and bytes from the File Data page (address0xFD00) of the Modbus IED.
6. If an error occurs during the transfer of any of the blocks, the master can re-read the bad block by reading from addresses 0xFC00 and 0xFE00 (the repeat File Parameters and File Data pages).
7. After the Modbus master receives the last File Data block, the master sends a DO ACK (Modbus 05-Force Single Coil) command to the Modbus IED to acknowledge the transfer has been completed.
8. After receiving the DO ACK, the Modbus IED deletes the transferred file from its memory.

4.2.1 Alstom Compatibility Mode

The 70 Series IED can be configured to operate in “Alstom Compatibility Mode” in order to meet the Alstom Modbus file transfer standard. The response procedure is outlined below.

1. The 70 Series IED will respond to the Fast Reading Byte (Modbus 07-Read Exception Status) command with bit 4 clear when no waveform capture files are available. The device will set bit 4 (b4 – Presence of a disturbance record not extracted) when a new record has been created.

2. The 70 Series IED will respond with the File Header data and open the new recorder file for reading.

3. The 70 Series IED prepares the first block (page) of both the parameter field and data field.

4. The 70 Series IED sends the File Parameters.

5. The 70 Series IED sends the File Data.

6. The 70 Series IED will re-send any requested blocks.

7. Since the 70 Series IED does not have coils, it will interpret any Modbus –05 Force Single Coil command as a DO ACK.

8. The 70 Series IED will respond to the DO ACK and will close and then delete the newly created record file.

The 70 Series IED is capable of communicating to various masters concurrently utilizing several protocols. The 70 Series IED is capable of storing Waveform, Disturbance and Trend recorder files. Some applications require that multiple masters have access to these files as well as other data generated by the 70 Series IED. To accommodate these numerous applications, the 70 Series IED’s Modbus file transfer can be configured to operate in several different modes. The “Alstom Compatibility Mode” previously described is just one such mode.

4.3 Basic File Transfer

The Modbus master MUST first read the File Header from the 70 Series IED prior to transferring a file. Reading the File Header serves two main purposes:

1. It informs the Modbus master of the size of the file to be transferred.

2. It requests that the 70 Series IED open the specified file.

If a file transfer is presently in progress on the specified 70 Series IED port, the device will respond with Modbus *Device Busy* response. If the file specified does not exist, the 70 Series IED will respond with the Modbus *Illegal Data Exception* response. If the specified file does exist, but the 70 Series IED cannot presently open the file, it will respond with the Modbus *Device Busy* response.

Next, the Modbus master has the option of reading the Parameter Header. The Parameter Header does not need to be read by the Modbus master. The Parameter Header does include information that the Modbus master may need.

The Modbus master then starts the actual file transfer. The Modbus master reads the required number of transfer blocks (determined from the file size) from the 70 Series IED. Each file transfer block contains up to 250 bytes of the file. The blocks are transferred sequentially by reading Modbus address 0xFD00. After the 70 Series IED sends a block of data, it automatically increments to the next block of data. The 70 Series IED will re-send the last block of data when Modbus Address 0xFE00 is read.

Once the Modbus master has received the entire file, it is recommended that the master send a Modbus *Force Single Coil* command to acknowledge receipt of the file. When the 70 Series IED receives the *Force Single Coil* command, it will close the file. If the 70 Series IED does not receive a *Force Single Coil* command, the file will remain open until the configured timeout (*New Block Timeout*) expires.

NOTE:

1) The Modbus *Read Holding Register* command requests 16-bit registers. If the file size has an odd number of bytes, the extra byte sent is always zero. It is the Modbus master's responsibility to strip off the last byte before recreating the file.

2) Reading the File Header automatically opens that file on the respective 70 Series IED Modbus port. That file will remain open until either a file transfer acknowledge (*Force Single Coil*) command is received or the *New Block Timeout* expires. Only one file can be opened at a time on an 70 Series IED Modbus port.

3) Selecting the file to transfer is described later in this document.

4.4 File Transfer Configuration

The Modbus file transfer configuration consists of three parameters, the *Select File* Register, the *Delete File* Register, and the *New Block Timeout*. As previously mentioned, the 70 Series IED is capable of generating several different recorder files. The *Select File* Register setting permits the 70 Series IED to automatically select the oldest file for download or allows the user to manually select which file to download. The *Delete File* Register setting permits the 70 Series IED to automatically delete the file after it is sent or allows the user to manually select which file to delete. The *New Block Timeout* parameter specifies how long to wait after a file transfer stalls before closing the file and aborting the transfer.

4.4.1 Modbus File System

The 70 Series IED stores and generates several files that are accessible via Modbus. These files include recorder files and a Modbus directory, which contains a list of Modbus files. Upon power-up, the 70 Series IED assigns a unique file number to each Modbus file. The association between the Modbus file names and Modbus file numbers remains constant until the 70 Series IED is re-booted. The file numbers associated with the Modbus directory file and log files always remain constant.

4.4.2 Modbus Directory

The Modbus Directory (DIR) File is an ASCII text file that contains a list of all Modbus files along with their associated File Parameter information.

File#	File Name	File Size	File Date	File Time	File Status
0	DIR				
1	NEXTFILE				
2	TR1.CFG	7877	11-27-2001	16:14	0
3	TR2.DAT	7052	11-27-2001	16:14	0
4	WV001.ZIP	104,576	10-15-2001	08:10	0
5	WV002.ZIP	104,488	10-15-2001	15:09	0
6	WV003.ZIP	104,790	11-08-2001	06:19	0

The Modbus Directory always includes at least four files (File# 0 thru File# 3). These files include the DIR (the directory file itself), the NEXTFILE (automated), the TR1.CFG (Trend Recorder configuration) and the TR1.DAT (Trend Recorder data) file.

If there are additional files accessible via Modbus, they will appear after the four files listed above. These files will be Recorder ZIP files and have File Numbers greater than '3'.

4.4.3 Downloads

4.4.3.1 Manual File Select

When a Modbus master requests a File Header from the 70 Series IED, the device checks the File Number stored in the *Select File* Register and provides the File Header for the Modbus file with the matching File Number. As previously mentioned the File Number for each Modbus file can be determined by downloading and viewing the Modbus DIR file.

To manually select the file to download:

1. Write a ‘0’ to the *Select File* Register to select the DIR file.
2. Transfer the DIR file.
3. View the DIR and determine the File Number to download.
4. Write the File Number to the *Select File* Register.
5. Transfer the file.

4.4.3.2 Automatic File Select

The 70 Series IED reserves File Number ‘1’ as NEXTFILE in its Modbus directory. When a ‘1’ is written to the *Select File* Register, the 70 Series IED will automatically select the oldest file not yet transferred via Modbus. The 70 Series IED will only auto-select event type (Recorder) files. The Trend Recorder file is continuously changing and will never be auto-selected.

To have the 70 Series IED automatically select which file to download:

1. Write a ‘1’ to the *Select File* Register to select NEXTFILE.
2. Transfer the file.

If no new files exist and a Modbus master requests a File Header with NEXTFILE (‘1’) in the *Select File* Register, the 70 Series IED will return a File Header with the File Size set to 0. If a new file does exist, the 70 Series IED will return a File Header with the File Size set to the correct size of the file it selected. When the Parameter Header for the selected file is sent it will contain all of the correct parameters (File Name, File Number, etc.).

Modbus masters can determine new file availability by requesting a File Header with the *Select File* Register set to NEXTFILE (‘1’) and checking if the File Size is non-zero. This is not recommended since it simpler and faster to poll the Fast Reading Byte.

4.4.4 Deleting a File

4.4.4.1 Manual File Delete

The 70 Series IED allows Modbus masters to manually delete a file by writing the File Number to the *Delete File* Register.

To manually delete a file:

1. Write a ‘0’ to the *Select File* Register to select the DIR file.
2. Transfer the DIR file.
3. View the DIR file and determine the File Number of the file you wish to delete.
4. Write the File Number to the *Delete File* Register.

4.4.4.2 Automatic File Delete

The 70 Series IED can be configured to automatically delete a file after the file has been transferred to a Modbus master. To select auto-delete mode, either write the NEXTFILE File Number (‘1’) to the *Delete File* Register or use the 70 Series Configurator to initialize the *Delete File* Register to ‘1’. The 70 Series IED will not delete the transferred file until the Modbus master confirms the transfer with a DO ACK (Modbus 05-Force Single Coil) command.

4.5 File Transfer Configuration Modes

There are several configuration modes for 70 Series IED Modbus file transfers; all of these fall under two different levels of configuration: non-volatile “run-time” configuration, and volatile “on-the-fly” configuration.

The 70 Series IED has a selectable Modbus Register set. Not including the *Select File* Register and *Delete File* Register in the configured Modbus register set prevents Modbus masters from changing the file transfer mode. This would ensure that the 70 Series IED always operates in the same Modbus file transfer mode. The only way to change the Modbus file transfer mode would be to use the 70 Series Configurator and re-boot the device.

The *Select File* Register and *Delete File* Register can each be independently added to the configured Modbus register set. By including the *Select File* Register and not the *Delete File* Register, Modbus masters would have the capability of manually selecting files for transfer but could not delete files.

Both the *Select File* Register and *Delete File* Register mode settings are stored in non-volatile memory (via INI files). If the *Select File* Register and *Delete File* Register are accessible to Modbus masters, the Modbus masters can change the *Select File* Register and *Delete File* Register non-volatile settings. If the *Select File* Register and *Delete File* Register are not accessible to Modbus masters (not configured in Modbus register set), the non-volatile configuration can only be changed by the 70 Series Configurator program. Non-volatile storage of the *Select File* and *Delete File* Register ensures that the 70 Series IED always returns to the same Modbus file transfer mode after re-booting.

4.5.1 Alstom Mode

In “Alstom Mode”, new files are automatically selected for transfer and automatically deleted after the transfer is confirmed by the master. To configure the 70 Series IED to operate in Alstom Mode, use the 70 Series Configurator to:

1. Set the *Select File* Register to ‘1’ (NEXTFILE).
2. Set the *Delete File* register to ‘1’ (NEXTFILE).
3. Make sure the *Select File* Register is NOT one of the configured Modbus registers.
4. Make sure that *Delete File* register is NOT one of the configured Modbus registers.

4.5.2 Alstom Mode – Auto-Delete Disabled

This mode is identical to standard Alstom Mode except that transferred files are not automatically deleted after they are transferred.

1. Set the *Select File* Register to ‘1’ (NEXTFILE).
2. Set the *Delete File* register to ‘0’
3. Make sure the *Select File* Register is NOT one of the configured Modbus registers.
4. Make sure that *Delete File* register is NOT one of the configured Modbus registers.

4.5.3 Manual File Transfer Mode – Delete Disabled

This mode allows Modbus masters to download a directory and manually select a file to transfer. Files can also be selected automatically by writing a ‘1’ (selecting NEXTFILE) to the Select File Register. Modbus masters cannot delete any files in this mode.

1. Set the *Select File* Register to ‘0’.
2. Set the *Delete File* register to ‘0.’
3. Make sure the *Select File* Register IS one of the configured Modbus registers.
4. Make sure that *Delete File* register is NOT one of the configured Modbus registers.

4.5.4 Manual File Transfer Mode – Automatic Delete

This mode allows Modbus masters to download a directory and manually select a file to transfer. Files can also be selected automatically by writing a ‘1’ (selecting NEXTFILE) to the Select File Register. The 70 Series IED will automatically delete files after the file is transferred and a confirmation has been received from the Modbus master. Modbus masters cannot manually delete files in this mode.

1. Set the *Select File* Register to ‘0’.
2. Set the *Delete File* register to ‘1.’
3. Make sure the *Select File* Register IS one of the configured Modbus registers.
4. Make sure that *Delete File* register is NOT one of the configured Modbus registers.

4.5.5 Manual File Transfer and Delete Mode

This mode allows Modbus masters to selectively transfer and delete all Modbus files.

1. Set the *Select File* Register to ‘0’.
2. Set the *Delete File* register to ‘0.’
3. Make sure the *Select File* Register IS one of the configured Modbus registers.
4. Make sure that *Delete File* register IS one of the configured Modbus registers.

APPENDIX A: 70 SERIES MODBUS REGISTER ASSIGNMENTS

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,001	Health	Health	Health	Start of Configurable Measurements
40,002	Health	Health	Health	
40,003	Register Set	RMS Amps A 1	Register Set	
40,004	Meter Type	RMS Amps B 1	Meter Type	
40,005	Firmware Version	RMS Amps C 1	Firmware Version	
40,006	Heart Beat	RMS Amps N 1	Heart Beat	
40,007	VT 1 Scale Factor	RMS Amps Residual	RMS Amps A 1	
40,008	VT 1 Scale Factor	RMS Volts A 1	RMS Amps B 1	
40,009	CT 1 Scale Factor	RMS Volts B 1	RMS Amps C 1	
40,010	CT 1 Scale Factor	RMS Volts C 1	RMS Amps A 2	
40,011	VT 2 Scale Factor	RMS Volts N 1	RMS Amps B 2	
40,012	VT 2 Scale Factor	RMS Volts AB 1	RMS Amps C 2	
40,013	CT 2 Scale Factor	RMS Volts BC 1	RMS Volts A 1	
40,014	CT 2 Scale Factor	RMS Volts CA 1	RMS Volts B 1	
40,015	RMS Volts A 1	RMS Volts A 2	RMS Volts C 1	
40,016	RMS Volts B 1	RMS Volts B 2	RMS Volts N 1	
40,017	RMS Volts C 1	RMS Volts C 2	RMS Volts AB 1	
40,018	RMS Volts N 1	RMS Volts N 2	RMS Volts BC 1	
40,019	RMS Volts R 1	RMS Volts AB 2	RMS Volts CA 1	
40,020	RMS Volts R 2	RMS Volts BC 2	RMS Volts A 2	
40,021	RMS Volts AB 1	RMS Volts CA 2	RMS Volts B 2	
40,022	RMS Volts BC 1	RMS Watts A 1	RMS Volts C 2	
40,023	RMS Volts CA 1	RMS Watts B 1	RMS Volts N 2	
40,024	RMS Amps A 1	RMS Watts C 1	RMS Volts AB 2	
40,025	RMS Amps B 1	RMS Watts Total 1	RMS Volts BC 2	
40,026	RMS Amps C 1	RMS VARs A 1	RMS Volts CA 2	
40,027	RMS Amps N 1	RMS VARs B 1	RMS Volts R 1	
40,028	RMS Volts A 2	RMS VARs C 1	RMS Volts R 2	
40,029	RMS Volts B 2	RMS VARs Total 1	RMS Watts A 1	
40,030	RMS Volts C 2	RMS VAs A 1	RMS Watts B 1	
40,031	RMS Volts N 2	RMS VAs B 1	RMS Watts C 1	
40,032	RMS Volts AB 2	RMS VAs C 1	RMS Watts Total 1	
40,033	RMS Volts BC 2	RMS VAs Total 1	RMS VARs A 1	
40,034	RMS Volts CA 2	Power Factor A 1	RMS VARs B 1	
40,035	RMS Amps A 2	Power Factor B 1	RMS VARs C 1	
40,036	RMS Amps B 2	Power Factor C 1	RMS VARs Total 1	
40,037	RMS Amps C 2	Power Factor Total 1	RMS VAs A 1	
40,038	Reserved for RMS Amps N 2	Frequency Volts A 1	RMS VAs B 1	
40,039	RMS Watts A 1	Frequency Volts B 1	RMS VAs C 1	
40,040	RMS Watts B 1	Frequency Volts C 1	RMS VAs Total 1	

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,041	RMS Watts C 1	Frequency Volts A 2	Power Factor A 1	
40,042	RMS Watts T 1	Frequency Volts B 2	Power Factor B 1	
40,043	RMS VARs A 1	Frequency Volts C 2	Power Factor C 1	
40,044	RMS VARs B 1	System Frequency	Power Factor Total 1	
40,045	RMS VARs C 1	Phase Angle Volts A 1- 2	RMS Watts A 2	
40,046	RMS VARs T 1	Phase Angle Volts B 1- 2	RMS Watts B 2	
40,047	RMS VAs A 1	Phase Angle Volts C 1- 2	RMS Watts C 2	
40,048	RMS VAs B 1	Phase Angle RMS Amps A 1 Harmonic 01	RMS Watts Total 2	
40,049	RMS VAs C 1	Phase Angle RMS Amps B 1 Harmonic 01	RMS VARs A 2	
40,050	RMS VAs T 1	Phase Angle RMS Amps C 1 Harmonic 01	RMS VARs B 2	
40,051	Power Factor A 1	Phase Angle RMS Volts A 1 Harmonic 01	RMS VARs C 2	
40,052	Power Factor B 1	Phase Angle RMS Volts B 1 Harmonic 01	RMS VARs Total 2	
40,053	Power Factor C 1	Phase Angle RMS Volts C 1 Harmonic 01	Reserved (returns 0)	
40,054	Power Factor T 1	VA/PF Calc. Type	Reserved (returns 0)	
40,055	Meter Type	Meter Type	Meter Type	
40,056	RMS Watts A 2	VT Scale Factor	RMS VAs A 2	
40,057	RMS Watts B 2	VT Scale Factor	RMS VAs B 2	
40,058	RMS Watts C 2	CT Scale Factor	RMS VAs C 2	
40,059	RMS Watts T 2	CT Scale Factor	RMS VAs Total 2	
40,060	RMS VARs A 2	Xfmr Ratio Volts A 1	Power Factor A 2	
40,061	RMS VARs B 2	Xfmr Ratio Volts A 1	Power Factor B 2	
40,062	RMS VARs C 2	Xfmr Ratio Volts B 1	Power Factor C 2	
40,063	RMS VARs T 2	Xfmr Ratio Volts B 1	Power Factor Total 2	
40,064	RMS VAs A 2	Xfmr Ratio Volts C 1	Reserved (returns 0)	
40,065	RMS VAs B 2	Xfmr Ratio Volts C 1	Reserved (returns 0)	
40,066	RMS VAs C 2	Xfmr Ratio Volts N 1	Reserved (returns 0)	
40,067	RMS VAs T 2	Xfmr Ratio Volts N 1	Reserved (returns 0)	
40,068	Reserved (returns 0)	Xfmr Ratio Volts A 2	Reserved (returns 0)	
40,069	Reserved (returns 0)	Xfmr Ratio Volts A 2	Reserved (returns 0)	
40,070	Reserved (returns 0)	Xfmr Ratio Volts B 2	Reserved (returns 0)	
40,071	Meter Type	Xfmr Ratio Volts B 2	Meter Type	
40,072	Power Factor A 2	Xfmr Ratio Volts C 2	Frequency Volts A 1	
40,073	Power Factor B 2	Xfmr Ratio Volts C 2	Frequency Volts B 1	
40,074	Power Factor C 2	Xfmr Ratio Volts N 2	Frequency Volts C 1	
40,075	Power Factor T 2	Xfmr Ratio Volts N 2	Frequency Volts A 2	
40,076	VA/PF Calc. Type	Xfmr Ratio Amps A 1	Frequency Volts B 2	
40,077	KWatt1-Hrs Normal	Xfmr Ratio Amps A 1	Frequency Volts C 2	
40,078	KWatt1-Hrs Normal	Xfmr Ratio Amps B 1	Frequency Volts R 1	
40,079	KWatt1-Hrs Reverse	Xfmr Ratio Amps B 1	Frequency Volts R 2	

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,080	KWatt1-Hrs Reverse	Xfmr Ratio Amps C 1	System Frequency	
40,081	KVAR1-Hrs Lag	Xfmr Ratio Amps C 1	Reserved for System Frequency 2	
40,082	KVAR1-Hrs Lag	Xfmr Ratio Amps N 1	Phase Angle Volts A 1 - 2	
40,083	KVAR1-Hrs Lead	Xfmr Ratio Amps N 1	Phase Angle Volts B 1 - 2	
40,084	KVAR1-Hrs Lead	User Gain Volts A 1	Phase Angle Volts C 1 - 2	
40,085	KWatt2-Hrs Normal	User Gain Volts B 1	Phase Angle Volts A 1 - R 1	
40,086	KWatt2-Hrs Normal	User Gain Volts C 1	Phase Angle Volts B 1 - R 1	
40,087	KWatt2-Hrs Reverse	User Gain Volts N 1	Phase Angle Volts C 1 - R 1	
40,088	KWatt2-Hrs Reverse	User Gain Volts A 2	Phase Angle Volts A 1 - R 2	
40,089	KVAR2-Hrs Lag	User Gain Volts B 2	Phase Angle Volts B 1 - R 2	
40,090	KVAR2-Hrs Lag	User Gain Volts C 2	Phase Angle Volts C 1 - R 2	
40,091	KVAR2-Hrs Lead	User Gain Volts N 2	Phase Angle RMS Amps A 1 Harmonic 01	
40,092	KVAR2-Hrs Lead	User Gain Amps A 1	Phase Angle RMS Amps B 1 Harmonic 01	
40,093	System Frequency	User Gain Amps B 1	Phase Angle RMS Amps C 1 Harmonic 01	
40,094	Reserved for System Frequency 2	User Gain Amps C 1	Phase Angle RMS Amps A 2 Harmonic 01	
40,095	Reserved (returns 0)	User Gain Amps N 1	Phase Angle RMS Amps B 2 Harmonic 01	
40,096	Reserved (returns 0)	User Phase Correction Volts A 1	Phase Angle RMS Amps C 2 Harmonic 01	
40,097	Reserved (returns 0)	User Phase Correction Volts B 1	Phase Angle RMS Volts A 1 Harmonic 01	
40,098	Reserved (returns 0)	User Phase Correction Volts C 1	Phase Angle RMS Volts B 1 Harmonic 01	
40,099	Reserved (returns 0)	User Phase Correction Volts N 1	Phase Angle RMS Volts C 1 Harmonic 01	
40,100	Reserved (returns 0)	User Phase Correction Volts A 2	Phase Angle RMS Volts A 2 Harmonic 01	
40,101	Reserved (returns 0)	User Phase Correction Volts B 2	Phase Angle RMS Volts B 2 Harmonic 01	
40,102	Reserved (returns 0)	User Phase Correction Volts C 2	Phase Angle RMS Volts C 2 Harmonic 01	
40,103	Reserved (returns 0)	User Phase Correction Volts N 2	VT 1 Scale Factor	
40,104	Reserved (returns 0)	User Phase Correction Amps A 1	VT 1 Scale Factor	
40,105	Reserved (returns 0)	User Phase Correction Amps B 1	CT 1 Scale Factor	
40,106	Reserved (returns 0)	User Phase Correction Amps C 1	CT 1 Scale Factor	
40,107	Reserved (returns 0)	User Phase Correction Amps N 1	VT 2 Scale Factor	
40,108	Reserved (returns 0)	Start of User Configurable Measurements	VT 2 Scale Factor	
40,109	Reserved (returns 0)		CT 2 Scale Factor	
40,110	Reserved (returns 0)		CT 2 Scale Factor	
40,111	Heartbeat		Xfmr Ratio Volts A 1	

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,112	VT 1 Scale Factor		Xfmr Ratio Volts A 1	
40,113	VT 1 Scale Factor		Xfmr Ratio Volts B 1	
40,114	CT 1 Scale Factor		Xfmr Ratio Volts B 1	
40,115	CT 1 Scale Factor		Xfmr Ratio Volts C 1	
40,116	System Frequency		Xfmr Ratio Volts C 1	
40,117	Demand RMS Amps A 1		Xfmr Ratio Volts N 1	
40,118	Demand RMS Amps B 1		Xfmr Ratio Volts N 1	
40,119	Demand RMS Amps C 1		Xfmr Ratio Volts A 2	
40,120	Demand RMS Amps N 1		Xfmr Ratio Volts A 2	
40,121	Max Demand RMS Amps A 1		Xfmr Ratio Volts B 2	
40,122	Max Demand RMS Amps B 1		Xfmr Ratio Volts B 2	
40,123	Max Demand RMS Amps C 1		Xfmr Ratio Volts C 2	
40,124	Max Demand RMS Amps N 1		Xfmr Ratio Volts C 2	
40,125	Demand RMS Volts A 1		Xfmr Ratio Volts N 2	
40,126	Demand RMS Volts B 1		Xfmr Ratio Volts N 2	
40,127	Demand RMS Volts C 1		Xfmr Ratio Volts R 1	
40,128	Demand RMS Volts N 1		Xfmr Ratio Volts R 1	
40,129	Max Demand RMS Volts A 1		Xfmr Ratio Volts R 2	
40,130	Max Demand RMS Volts B 1		Xfmr Ratio Volts R 2	
40,131	Max Demand RMS Volts C 1		Xfmr Ratio Amps A 1	
40,132	Max Demand RMS Volts N 1		Xfmr Ratio Amps A 1	
40,133	Min Demand RMS Volts A 1		Xfmr Ratio Amps B 1	
40,134	Min Demand RMS Volts B 1		Xfmr Ratio Amps B 1	
40,135	Min Demand RMS Volts C 1		Xfmr Ratio Amps C 1	
40,136	Min Demand RMS Volts N 1		Xfmr Ratio Amps C 1	
40,137	Demand RMS Volts AB 1		Xfmr Ratio Amps N 1	
40,138	Demand RMS Volts BC 1		Xfmr Ratio Amps N 1	
40,139	Demand RMS Volts CA 1		Xfmr Ratio Amps A 2	
40,140	Min Demand RMS Volts AB 1		Xfmr Ratio Amps A 2	
40,141	Min Demand RMS Volts BC 1		Xfmr Ratio Amps B 2	
40,142	Min Demand RMS Volts CA 1		Xfmr Ratio Amps B 2	
40,143	Max Demand RMS Volts AB 1		Xfmr Ratio Amps C 2	
40,144	Max Demand RMS Volts BC 1		Xfmr Ratio Amps C 2	
40,145	Max Demand RMS Volts CA 1		Reserved for Xfmr Ratio Amps N 2	
40,146	Demand RMS Watts Total 1		Reserved for Xfmr Ratio Amps N 2	
40,147	Demand RMS VARs Total 1		User Gain Volts A 1	
40,148	Demand RMS VAs Total 1		User Gain Volts B 1	
40,149	Max Demand RMS Watts Total 1		User Gain Volts C 1	
40,150	Max Demand RMS VARs Total 1		User Gain Volts N 1	
40,151	Max Demand RMS VAs Total 1		User Gain Volts A 2	

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,152	Min Demand RMS Watts Total 1		User Gain Volts B 2	
40,153	Min Demand RMS VARs Total 1		User Gain Volts C 2	
40,154	Min Demand RMS VAs Total 1		User Gain Volts N 2	
40,155	VT 2 Scale Factor		User Gain Volts R 1	
40,156	VT 2 Scale Factor		User Gain Volts R 2	
40,157	CT 2 Scale Factor		User Gain Amps A 1	
40,158	CT 2 Scale Factor		User Gain Amps B 1	
40,159	Reserved for System Frequency 2		User Gain Amps C 1	
40,160	Demand RMS Amps A 2		User Gain Amps N 2	
40,161	Demand RMS Amps B 2		User Gain Amps A 2	
40,162	Demand RMS Amps C 2		User Gain Amps B 2	
40,163	Reserved for Demand RMS Amps N 2		User Gain Amps C 2	
40,164	Max Demand RMS Amps A 2		Reserved for User Gain Amsp N 2	
40,165	Max Demand RMS Amps B 2		User Phase Correction Volts A 1	
40,166	Max Demand RMS Amps C 2		User Phase Correction Volts B 1	
40,167	Reserved for Max Demand RMS Amps N 2		User Phase Correction Volts C 1	
40,168	Demand RMS Volts A 2		User Phase Correction Volts N 1	
40,169	Demand RMS Volts B 2		User Phase Correction Volts A 2	
40,170	Demand RMS Volts C 2		User Phase Correction Volts B 2	
40,171	Demand RMS Volts N 2		User Phase Correction Volts C 2	
40,172	Max Demand RMS Volts A 2		User Phase Correction Volts N 2	
40,173	Max Demand RMS Volts B 2		User Phase Correction Volts R 1	
40,174	Max Demand RMS Volts C 2		User Phase Correction Volts R 2	
40,175	Max Demand RMS Volts N 2		User Phase Correction Amps A 1	
40,176	Min Demand RMS Volts A 2		User Phase Correction Amps B 1	
40,177	Min Demand RMS Volts B 2		User Phase Correction Amps C 1	
40,178	Min Demand RMS Volts C 2		User Phase Correction Amps N 1	
40,179	Min Demand RMS Volts N 2		User Phase Correction Amps A 2	
40,180	Demand RMS Volts AB 2		User Phase Correction Amps B 2	
40,181	Demand RMS Volts BC 2		User Phase Correction Amps C 2	

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,182	Demand RMS Volts CA 2		Reserved For User Phase Correction Amps N 2	
40,183	Min Demand RMS Volts AB 2		VA/PF Calc. Type	
40,184	Min Demand RMS Volts BC 2		File Select Rgstr	
40,185	Min Demand RMS Volts CA 2		File Delete Rgstr	
40,186	Max Demand RMS Volts AB 2		Reserved (returns 0)	
40,187	Max Demand RMS Volts BC 2		Reserved (returns 0)	
40,188	Max Demand RMS Volts CA 2		Reserved (returns 0)	
40,189	Demand RMS Watts Total 2		Reserved (returns 0)	
40,190	Demand RMS VARs Total 2		Reserved (returns 0)	
40,191	Demand RMS VAs Total 2		Reserved (returns 0)	
40,192	Max Demand RMS Watts Total 2		Reserved (returns 0)	
40,193	Max Demand RMS VARs Total 2		Reserved (returns 0)	
40,194	Max Demand RMS VAs Total 2		Reserved (returns 0)	
40,195	Min Demand RMS Watts Total 2		Reserved (returns 0)	
40,196	Min Demand RMS VARs Total 2		Start of User Configurable Measurements	
40,197	Min Demand RMS VAs Total 2			
40,198	Reserved (returns 0)			
40,199	Reserved (returns 0)			
40,200	Reserved (returns 0)			
40,201	Reserved (returns 0)			
40,202	Reserved (returns 0)			
40,203	Reserved (returns 0)			
40,204	Reserved (returns 0)			
40,205	Reserved (returns 0)			
40,206	Reserved (returns 0)			
40,207	Reserved (returns 0)			
40,208	Reserved (returns 0)			
40,209	Reserved (returns 0)			
40,210	Reserved (returns 0)			
40,211	Phase Angle Volts A 1- 2			
40,212	Phase Angle Volts B 1- 2			
40,213	Phase Angle Volts C 1- 2			
40,214	Phase Angle Volts A 1- R 1			
40,215	Phase Angle Volts B 1- R 1			
40,216	Phase Angle Volts C 1- R 1			
40,217	Phase Angle Volts A 1- R 2			
40,218	Phase Angle Volts B 1- R 2			
40,219	Phase Angle Volts C 1- R 2			
40,220	RMS Volts A 1			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,221	RMS Volts B 1			
40,222	RMS Volts C 1			
40,223	RMS Volts R 1			
40,224	RMS Volts R 2			
40,225	Frequency Volts A 1			
40,226	Frequency Volts B 1			
40,227	Frequency Volts C 1			
40,228	Frequency R 1			
40,229	Frequency R 2			
40,230	RMS Volts A 2			
40,231	RMS Volts B 2			
40,232	RMS Volts C 2			
40,233	Frequency Volts A 2			
40,234	Frequency Volts B 2			
40,235	Frequency Volts C 2			
40,236	Reserved (returns 0)			
40,237	Reserved (returns 0)			
40,238	Reserved (returns 0)			
40,239	Reserved (returns 0)			
40,240	Reserved (returns 0)			
40,241	Reserved (returns 0)			
40,242	Reserved (returns 0)			
40,243	Reserved (returns 0)			
40,244	Reserved (returns 0)			
40,245	Reserved (returns 0)			
40,246	Reserved (returns 0)			
40,247	Reserved (returns 0)			
40,248	Reserved (returns 0)			
40,249	Reserved (returns 0)			
40,250	Reserved (returns 0)			
40,251	DSP Version			
40,252	Protocol Version			
40,253	Config Register 1			
40,254	Config Register 2			
40,255	Tag Register			
40,256	VT 1 Scale Factor			
40,257	VT 1 Scale Factor			
40,258	CT 1 Scale Factor			
40,259	CT 1 Scale Factor			
40,260	VT 2 Scale Factor			
40,261	VT 2 Scale Factor			
40,262	CT 2 Scale Factor			
40,263	CT 2 Scale Factor			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,264	Xfmr Ratio Volts A 1			
40,265	Xfmr Ratio Volts A 1			
40,266	Xfmr Ratio Volts B 1			
40,267	Xfmr Ratio Volts B 1			
40,268	Xfmr Ratio Volts C 1			
40,269	Xfmr Ratio Volts C 1			
40,270	Xfmr Ratio Volts N 1			
40,271	Xfmr Ratio Volts N 1			
40,272	Xfmr Ratio Amps A 1			
40,273	Xfmr Ratio Amps A 1			
40,274	Xfmr Ratio Amps B 1			
40,275	Xfmr Ratio Amps B 1			
40,276	Xfmr Ratio Amps C 1			
40,277	Xfmr Ratio Amps C 1			
40,278	Xfmr Ratio Amps N 1			
40,279	Xfmr Ratio Amps N 1			
40,280	Xfmr Ratio Volts A 2			
40,281	Xfmr Ratio Volts A 2			
40,282	Xfmr Ratio Volts B 2			
40,283	Xfmr Ratio Volts B 2			
40,284	Xfmr Ratio Volts C 2			
40,285	Xfmr Ratio Volts C 2			
40,286	Xfmr Ratio Volts N 2			
40,287	Xfmr Ratio Volts N 2			
40,288	Xfmr Ratio Amps A 2			
40,289	Xfmr Ratio Amps A 2			
40,290	Xfmr Ratio Amps B 2			
40,291	Xfmr Ratio Amps B 2			
40,292	Xfmr Ratio Amps C 2			
40,293	Xfmr Ratio Amps C 2			
40,294	Reserved for Xfmr Ratio Amps N 2			
40,295	Reserved for Xfmr Ratio Amps N 2			
40,296	Xfmr Ratio Volts R 1			
40,297	Xfmr Ratio Volts R 1			
40,298	Xfmr Ratio Volts R 2			
40,299	Xfmr Ratio Volts R 2			
40,300	File Select Rgstr			
40,301	File Delete Rgstr			
40,302	Time Sync Error (msec)			
40,303	IrigB Time Sync (0 or 1)			
40,304	(UCA) Network Time (0 or 1)			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,305	SNTP Time Sync (0 or 1)			
40,306	DNP Time Sync (0 or 1)			
40,307	Reserved (returns 0)			
40,308	Best Clock Source (0 thru 5)			
40,309	Reserved (returns 0)			
40,310	Reserved (returns 0)			
40,311	Reserved (returns 0)			
40,312	Reserved (returns 0)			
40,313	Reserved (returns 0)			
40,314	Reserved (returns 0)			
40,315	Reserved (returns 0)			
40,316	Reserved (returns 0)			
40,317	Reserved (returns 0)			
40,318	Reserved (returns 0)			
40,319	Reserved (returns 0)			
40,320	Reserved (returns 0)			
40,321	DIO#0 Input			
40,322	DIO#0 Output 1			
40,323	DIO#0 Output 2			
40,324	DIO#0 Output 3			
40,325	DIO#0 Output 4			
40,326	DIO#1 Input			
40,327	DIO#1 Output 1			
40,328	DIO#1 Output 2			
40,329	DIO#1 Output 3			
40,330	DIO#1 Output 4			
40,331	DIO#2 Input			
40,332	DIO#2 Output 1			
40,333	DIO#2 Output 2			
40,334	DIO#2 Output 3			
40,335	DIO#2 Output 4			
40,336	DIO#3 Input			
40,337	DIO#3 Output 1			
40,338	DIO#3 Output 2			
40,339	DIO#3 Output 3			
40,340	DIO#3 Output 4			
40,341	DIO#4 Input			
40,342	DIO#4 Output 1			
40,343	DIO#4 Output 2			
40,344	DIO#4 Output 3			
40,345	DIO#4 Output 4			
40,346	DIO#5 Input			
40,347	DIO#5 Output 1			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,348	DIO#5 Output 2			
40,349	DIO#5 Output 3			
40,350	DIO#5 Output 4			
40,351	DIO#6 Input			
40,352	DIO#6 Output 1			
40,353	DIO#6 Output 2			
40,354	DIO#6 Output 3			
40,355	DIO#6 Output 4			
40,356	Reserved (returns 0)			
40,357	Reserved (returns 0)			
40,358	Reserved (returns 0)			
40,359	Reserved (returns 0)			
40,360	Reserved (returns 0)			
40,361	Reserved (returns 0)			
40,362	Reserved (returns 0)			
40,363	Reserved (returns 0)			
40,364	Reserved (returns 0)			
40,365	Reserved (returns 0)			
40,366	Reserved (returns 0)			
40,367	Reserved (returns 0)			
40,368	Reserved (returns 0)			
40,369	Reserved (returns 0)			
40,370	Reserved (returns 0)			
40,371	Reset Energy			
40,372	Reset Demand Amps			
40,373	Reset Demand Volts			
40,374	Reset Demand Power			
40,375	Reset Demand Harmonic			
40,376	Reset Received [UCA] GOOSE Parameters **[NOTE: This is now referred to as GSSE]**			
40,377	WR1 Recorder Started			
40,378	WR1 Recorder Completed			
40,379	WR1 Recorder Memory Low			
40,380	Trigger WR1 Recorder			
40,381	WR1 Recorder Active			
40,382	WR2 Recorder Started			
40,383	WR2 Recorder Completed			
40,384	WR2 Recorder Memory Low			
40,385	Trigger WR2 Recorder			
40,386	WR2 Recorder Active			
40,387	DR1 Recorder Started			
40,388	DR1 Recorder Completed			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,389	DR1 Recorder Memory Low			
40,390	Trigger DR1 Recorder			
40,391	DR1 Recorder Active			
40,392	DR2 Recorder Started			
40,393	DR2 Recorder Completed			
40,394	DR2 Recorder Memory Low			
40,395	Trigger DR2 Recorder			
40,396	DR2 Recorder Active			
40,397	Any Recorder Started			
40,398	Any Recorder Completed			
40,399	Any Recorder Memory Low			
40,400	Any Recorder Active			
40,401	Reserved (returns 0)			
40,402	Reserved (returns 0)			
40,403	Reserved (returns 0)			
40,404	Reserved (returns 0)			
40,405	Reserved (returns 0)			
40,406	Reserved (returns 0)			
40,407	Reserved (returns 0)			
40,408	Reserved (returns 0)			
40,409	Reserved (returns 0)			
40,410	Reserved (returns 0)			
40,411	RMS Volts A 1			
40,412	RMS Volts B 1			
40,413	RMS Volts C 1			
40,414	Phase Angle RMS Volts A 1 Harmonic 01			
40,415	Phase Angle RMS Volts B 1 Harmonic 01			
40,416	Phase Angle RMS Volts C 1 Harmonic 01			
40,417	RMS Amps A 1			
40,418	RMS Amps B 1			
40,419	RMS Amps C 1			
40,420	RMS Amps N 1			
40,421	Phase Angle RMS Amps A 1 Harmonic 01			
40,422	Phase Angle RMS Amps B 1 Harmonic 01			
40,423	Phase Angle RMS Amps C 1 Harmonic 01			
40,424	Phase Angle RMS Amps N 1 Harmonic 01			
40,425	RMS Volts A 2			
40,426	RMS Volts B 2			
40,427	RMS Volts C 2			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,428	Phase Angle RMS Volts A 2 Harmonic 01			
40,429	Phase Angle RMS Volts B 2 Harmonic 01			
40,430	Phase Angle RMS Volts C 2 Harmonic 01			
40,431	RMS Amps A 2			
40,432	RMS Amps B 2			
40,433	RMS Amps C 2			
40,434	Reserved for RMS Amps N 2			
40,435	Phase Angle RMS Amps A 2 Harmonic 01			
40,436	Phase Angle RMS Amps B 2 Harmonic 01			
40,437	Phase Angle RMS Amps C 2 Harmonic 01			
40,438	Reserved Phase Angle RMS Amps N 2 Harmonic 01			
40,439	Reserved (returns 0)			
40,440	Reserved (returns 0)			
40,441	Reserved (returns 0)			
40,442	Reserved (returns 0)			
40,443	Reserved (returns 0)			
40,444	Reserved (returns 0)			
40,445	Reserved (returns 0)			
40,446	Reserved (returns 0)			
40,447	Reserved (returns 0)			
40,448	Reserved (returns 0)			
40,449	Reserved (returns 0)			
40,450	Reserved (returns 0)			
40,451	Virtual Status Input 1			
40,452	Virtual Status Input 2			
40,453	Virtual Status Input 3			
40,454	Virtual Status Input 4			
40,455	Virtual Status Input 5			
40,456	Virtual Status Input 6			
40,457	Virtual Status Input 7			
40,458	Virtual Status Input 8			
40,459	Virtual Status Input 9			
40,460	Virtual Status Input 10			
40,461	Virtual Status Input 11			
40,462	Virtual Status Input 12			
40,463	Virtual Status Input 13			
40,464	Virtual Status Input 14			
40,465	Virtual Status Input 15			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,466	Virtual Status Input 16			
40,467	Virtual Status Input 17			
40,468	Virtual Status Input 18			
40,469	Virtual Status Input 19			
40,470	Virtual Status Input 20			
40,471	Virtual Status Input 21			
40,472	Virtual Status Input 22			
40,473	Virtual Status Input 23			
40,474	Virtual Status Input 24			
40,475	Virtual Status Input 25			
40,476	Virtual Status Input 26			
40,477	Virtual Status Input 27			
40,478	Virtual Status Input 28			
40,479	Virtual Status Input 29			
40,480	Virtual Status Input 30			
40,481	Virtual Status Input 31			
40,482	Virtual Status Input 32			
40,483	Virtual Status Output Point 1			
40,484	Virtual Status Output Point 2			
40,485	Virtual Status Output Point 3			
40,486	Virtual Status Output Point 4			
40,487	Virtual Status Output Point 5			
40,488	Virtual Status Output Point 6			
40,489	Virtual Status Output Point 7			
40,490	Virtual Status Output Point 8			
40,491	Virtual Status Output Point 9			
40,492	Virtual Status Output Point 10			
40,493	Virtual Status Output Point 11			
40,494	Virtual Status Output Point 12			
40,495	Virtual Status Output Point 13			
40,496	Virtual Status Output Point 14			
40,497	Virtual Status Output Point 15			
40,498	Virtual Status Output Point 16			
40,499	Virtual Status Output Point 17			
40,500	Virtual Status Output Point 18			
40,501	Virtual Status Output Point 19			
40,502	Virtual Status Output Point 20			
40,503	Virtual Status Output Point 21			
40,504	Virtual Status Output Point 22			
40,505	Virtual Status Output Point 23			
40,506	Virtual Status Output Point 24			
40,507	Virtual Status Output Point 25			
40,508	Virtual Status Output Point 26			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,509	Virtual Status Output Point 27			
40,510	Virtual Status Output Point 28			
40,511	Virtual Status Output Point 29			
40,512	Virtual Status Output Point 30			
40,513	Virtual Status Output Point 31			
40,514	Virtual Status Output Point 32			
40,515	Reserved (returns 0)			
40,516	Reserved (returns 0)			
40,517	Reserved (returns 0)			
40,518	Reserved (returns 0)			
40,519	Reserved (returns 0)			
40,520	Reserved (returns 0)			
40,521	Reserved (returns 0)			
40,522	Reserved (returns 0)			
40,523	Reserved (returns 0)			
40,524	Reserved (returns 0)			
40,525	Reserved (returns 0)			
40,526	Reserved (returns 0)			
40,527	Reserved (returns 0)			
40,528	Reserved (returns 0)			
40,529	Reserved (returns 0)			
40,530	Reserved (returns 0)			
40,531	Impedance A 1			
40,532	Impedance B 1			
40,533	Impedance C 1			
40,534	Resistance A 1			
40,535	Resistance B 1			
40,536	Resistance C 1			
40,537	Reactance A 1			
40,538	Reactance B 1			
40,539	Reactance C 1			
40,540	Phase Angle A Volts - Amps 1			
40,541	Phase Angle B Volts - Amps 1			
40,542	Phase Angle C Volts - Amps 1			
40,543	Impedance A 2			
40,544	Impedance B 2			
40,545	Impedance C 2			
40,546	Resistance A 2			
40,547	Resistance B 2			
40,548	Resistance C 2			
40,549	Reactance A 2			
40,550	Reactance B 2			
40,551	Reactance C 2			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,552	Phase Angle A Volts - Amps 2			
40,553	Phase Angle B Volts - Amps 2			
40,554	Phase Angle C Volts - Amps 2			
40,555	Reserved (returns 0)			
40,556	Reserved (returns 0)			
40,557	Reserved (returns 0)			
40,558	Reserved (returns 0)			
40,559	Reserved (returns 0)			
40,560	Reserved (returns 0)			
40,561	Reserved (returns 0)			
40,562	Reserved (returns 0)			
40,563	Reserved (returns 0)			
40,564	Reserved (returns 0)			
40,565	Reserved (returns 0)			
40,566	Reserved (returns 0)			
40,567	Reserved (returns 0)			
40,568	Reserved (returns 0)			
40,569	Reserved (returns 0)			
40,570	Reserved (returns 0)			
40,571	Reserved (returns 0)			
40,572	TI#1 Input 1			
40,573	TI#1 Input 2			
40,574	TI#1 Input 3			
40,575	TI#1 Input 4			
40,576	TI#1 Input 5			
40,577	TI#1 Input 6			
40,578	TI#1 Input 7			
40,579	TI#1 Input 8			
40,580	TI#2 Input 1			
40,581	TI#2 Input 2			
40,582	TI#2 Input 3			
40,583	TI#2 Input 4			
40,584	TI#2 Input 5			
40,585	TI#2 Input 6			
40,586	TI#2 Input 7			
40,587	TI#2 Input 8			
40,588	TI#3 Input 1			
40,589	TI#3 Input 2			
40,590	TI#3 Input 3			
40,591	TI#3 Input 4			
40,592	TI#3 Input 5			
40,593	TI#3 Input 6			
40,594	TI#3 Input 7			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,595	TI#3 Input 8			
40,596	TI#4 Input 1			
40,597	TI#4 Input 2			
40,598	TI#4 Input 3			
40,599	TI#4 Input 4			
40,600	TI#4 Input 5			
40,601	TI#4 Input 6			
40,602	TI#4 Input 7			
40,603	TI#4 Input 8			
40,604	TI#5 Input 1			
40,605	TI#5 Input 2			
40,606	TI#5 Input 3			
40,607	TI#5 Input 4			
40,608	TI#5 Input 5			
40,609	TI#5 Input 6			
40,610	TI#5 Input 7			
40,611	TI#5 Input 8			
40,612	TI#6 Input 1			
40,613	TI#6 Input 2			
40,614	TI#6 Input 3			
40,615	TI#6 Input 4			
40,616	TI#6 Input 5			
40,617	TI#6 Input 6			
40,618	TI#6 Input 7			
40,619	TI#6 Input 8			
40,620	TI#7 Input 1			
40,621	TI#7 Input 2			
40,622	TI#7 Input 3			
40,623	TI#7 Input 4			
40,624	TI#7 Input 5			
40,625	TI#7 Input 6			
40,626	TI#7 Input 7			
40,627	TI#7 Input 8			
40,628	Reserved (returns 0)			
40,629	Reserved (returns 0)			
40,630	Reserved (returns 0)			
40,631	Reserved (returns 0)			
40,632	Reserved (returns 0)			
40,633	Reserved (returns 0)			
40,634	Reserved (returns 0)			
40,635	Reserved (returns 0)			
40,636	Reserved (returns 0)			
40,637	Reserved (returns 0)			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,638	Reserved (returns 0)			
40,639	Reserved (returns 0)			
40,640	Reserved (returns 0)			
40,641	RMS Volts A 1 Harmonic 00			
40,642	RMS Volts B 1 Harmonic 00			
40,643	RMS Volts C 1 Harmonic 00			
40,644	RMS Volts AB 1 Harmonic 00			
40,645	RMS Volts BC 1 Harmonic 00			
40,646	RMS Volts CA 1 Harmonic 00			
40,647	RMS Amps A 1 Harmonic 00			
40,648	RMS Amps B 1 Harmonic 00			
40,649	RMS Amps C 1 Harmonic 00			
40,650	RMS Amps N 1 Harmonic 00			
40,651	RMS Volts A 2 Harmonic 00			
40,652	RMS Volts B 2 Harmonic 00			
40,653	RMS Volts C 2 Harmonic 00			
40,654	RMS Volts AB 2 Harmonic 00			
40,655	RMS Volts BC 2 Harmonic 00			
40,656	RMS Volts CA 2 Harmonic 00			
40,657	RMS Amps A 2 Harmonic 00			
40,658	RMS Amps B 2 Harmonic 00			
40,659	RMS Amps C 2 Harmonic 00			
40,660	Reserved for RMS Amps N 2 Harmonic 00			
40,661	Phase Angle RMS Volts A 1 Harmonic 00			
40,662	Phase Angle RMS Volts B 1 Harmonic 00			
40,663	Phase Angle RMS Volts C 1 Harmonic 00			
40,664	Phase Angle RMS Volts AB 1 Harmonic 00			
40,665	Phase Angle RMS Volts BC 1 Harmonic 00			
40,666	Phase Angle RMS Volts CA 1 Harmonic 00			
40,667	Phase Angle RMS Amps A 1 Harmonic 00			
40,668	Phase Angle RMS Amps B 1 Harmonic 00			
40,669	Phase Angle RMS Amps C 1 Harmonic 00			
40,670	Phase Angle RMS Amps N 1 Harmonic 00			
40,671	Phase Angle RMS Volts A 2 Harmonic 00			

Modbus Address	HAF Harmonic Advanced Fixed	SFC Single Feeder Configurable	DFC Dual Feeder Configurable	TUC Totally User Configurable
40,672	Phase Angle RMS Volts B 2 Harmonic 00			
40,673	Phase Angle RMS Volts C 2 Harmonic 00			
40,674	Phase Angle RMS Volts AB 2 Harmonic 00			
40,675	Phase Angle RMS Volts BC 2 Harmonic 00			
40,676	Phase Angle RMS Volts CA 2 Harmonic 00			
40,677	Phase Angle RMS Amps A 2 Harmonic 00			
40,678	Phase Angle RMS Amps B 2 Harmonic 00			
40,679	Phase Angle RMS Amps C 2 Harmonic 00			
40,680	Reserved (returns 0)			
40,681	Reserved (returns 0)			
40,682	Reserved (returns 0)			
40,683	Reserved (returns 0)			
40,684	Reserved (returns 0)			
40,685	Reserved (returns 0)			
	Repeats harmonic values listed above for remaining harmonics through register 43525			

Alstom Grid

Alstom Grid Worldwide Contact Centre

www.alstom.com/grid/contactcentre/

Tel: +44 (0) 1785 250 070

www.alstom.com

GRID ALSTOM