User's Manual - Modbus
EMX – User Interface and Modbus Communications Guide

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Rev.	Release Date	By	Description of Change	ECR
0A		NAK	Initial Release	---
0B		NJS	Updates to point list	---
0C		NJS	Updates for logging	---
0D		RJC	Updates to registers and descriptions for logging	---

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See Also:

152-0390 *EMX Installation Instructions*

154-0041 *EMX BACnet Protocol Guide*

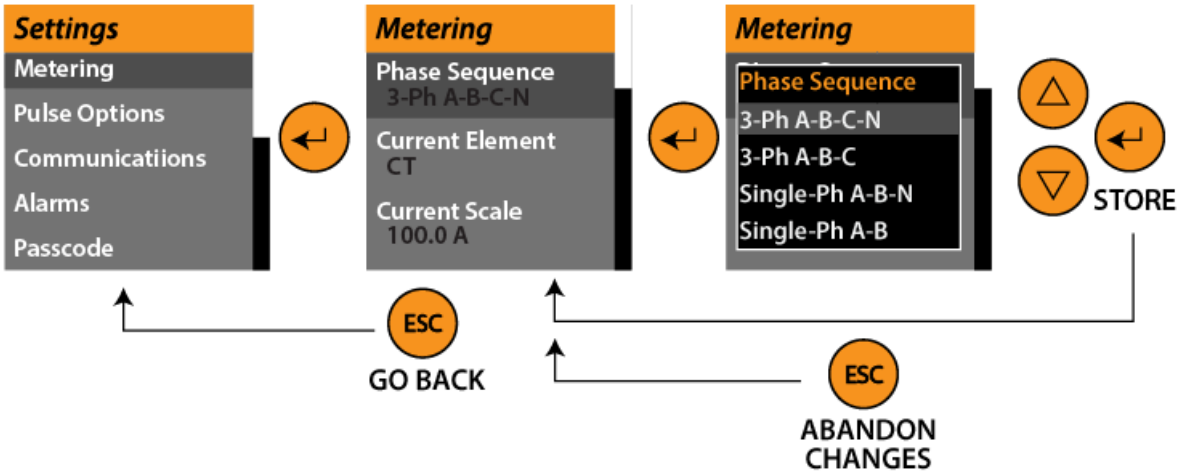
Display Navigation

Congratulations on installing your new Senva EMX energy meter! This *Modbus Protocol Guide* assumes the first stage of installation is complete, with the meter and any CTs connected and powered. The OLED display should show the home screen when any button is pressed. If not, refer to the separate *Installation Instructions* before continuing. Now, only the network configuration remains between you and the data.

From any screen, press the ENTER button to access the settings menu.

You can make selections using the UP and DOWN arrows and then pressing ENTER to proceed to that menu or setting.

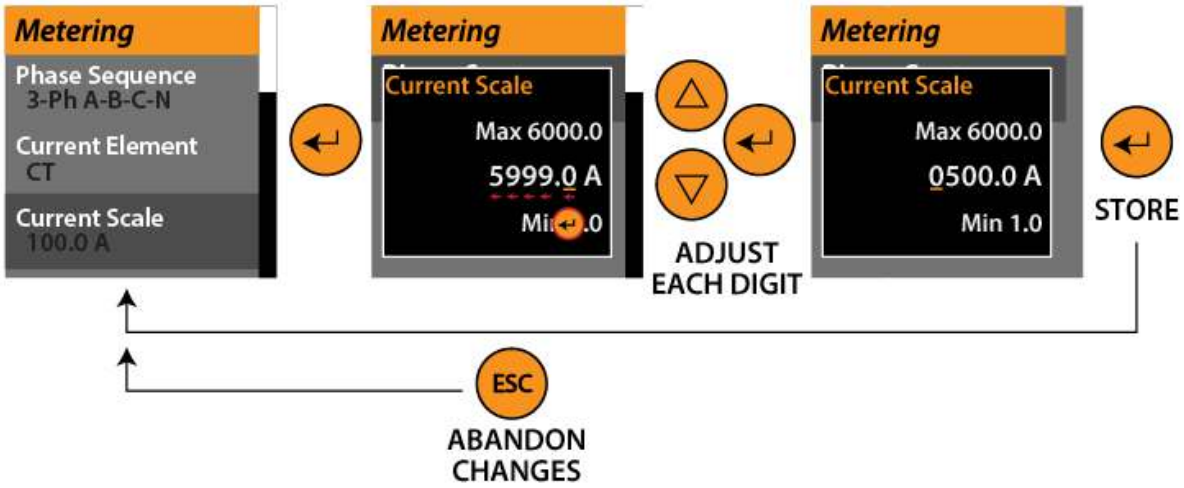
From any menu, press the ESC button to go back one menu.



To change a value, use the UP and DOWN arrows to set each digit and the ENTER button to move the cursor left.

Once each digit has been set, hit ENTER a final time to return to the previous menu.

To abandon changes at any time, you may hit ESC.



Setup Registers and Parameters

Setup registers and parameters are available in 6 groups in the settings menu using the display or they may also be accessed using Modbus communications.

Settings

Settings are available in the following groups on the display. A parameter list is provided in the following sections.

- **Metering** – Adjust metering parameters such as voltage and current scaling, phase sequencing, and display units.
- **Pulse Output** – Adjust the units, duration, and source of the two pulse outputs.
- **Communications** – Set communications parameters such as protocol, baud rate, parity, and addressing.
- **Alarms** - Enable or disable alarms and set trip points.
- **Passcode** – Choose a passcode to lock device.
- **Advanced** – View firmware versions or initiate a factory reset.

The following sections detail how to adjust settings over the Modbus interface. All settings are stored in non-volatile memory. Stored values will not be lost if the meter experiences a power loss.

R/W:
R = Readable Only
R/W = Read and writeable

Type, Min, Max:
U16 = UINT16 16-bit unsigned integer; min/max values listed

Scale:
Values must be multiplied by this scale factor to be read correctly. 15 * 0.1 = 1.5. When writing the value should be divided by the scale before being written. 1.5 / 0.1 = 15.

Modbus Function Codes:
The EMX setting registers support the following Modbus function codes:

- 0x03 Read Holding Registers
- 0x04 Read Input Register
- 0x06 Read Single Holding Register
- 0x10 Write Multiple Holding Registers

Metering

Description		Reg.	R/W	Min	Max	Default	Scale	Units
Phase Configuration	1-ABCN, 2-ABC, 3-ABN, 4-AB,	2000	R/W	0	3	1	N/A	N/A
Current Element	1-Current Transformer, 2-Rogowski Coil	2001	R/W	0	1	1	N/A	N/A
Current Scale	See note 1	2002	R/W	10	60000	10	0.1	Amps per 0.333 Volts
Current Orientation	For phases A, B, C: 1- +, +, + 2- +, +, - 3- +, -, + 4- +, -, - 5- -, +, + 6- -, +, - 7- -, -, + 8- -, -, -	2003	R/W	0	7	1	N/A	N/A
Voltage Scale	See note 2	2004	R/W	1	32000	100	0.01	Volts per Volt
Display Units	1-IEC Units, 2-IEEE Units	2005	R/W	0	1	1	N/A	N/A

1. Current scale is the primary side current of a 0.333V CT. CTs with an output voltage exceeding 0.333V should not be used. For a CT ratio of 20A / 0.333 V this will be 20.0 * 10 = 200. If a Rogowski coil is installed this value will need to be calculated from the coils mV/1000A rating. Rogowski conversion is calculated by (333.33 mV / x mV) *1000A * 10(scale).
2. Voltage scale is the PT ratio expressed as a decimal and multiplied by 100. A potential transformer of 25:10 would give a ratio of 25 / 10 = 2.5, appropriately scaled it would be 2.5*100 = 250.

Pulse Output

Description		Reg.	R/W	Min	Max	Default
Pulse Out 1 Source	1-Import Wh 2-Export Wh 3-Import VARh 4-Export VARh 5-Mirror Input 1 6-Mirror Input 2 7-Alarm Normally Open 8-Alarm Normally Closed 9-Phase Loss Normally Open 10-Phase Loss Normally Closed	2006	R/W	0	9	1

Description		Reg.	R/W	Min	Max	Default
Pulse Out 1 Wh	1-1 Wh per pulse 2-10 Wh per pulse 3-100 Wh per pulse 4-1000 Wh per pulse 5-10000 Wh per pulse	2007	R/W	0	4	1
Pulse Out 1 Duration	1-10ms 2-25ms 3-50ms 4-100ms 5-250ms 6-500ms	2008	R/W	0	5	1
Pulse Out 2 Source	1-Import Wh 2-Export Wh 3-Import VARh 4-Export VARh 5-Mirror Input 1 6-Mirror Input 2 7-Alarm Normally Open 8-Alarm Normally Closed 9-Phase Loss Normally Open 10-Phase Loss Normally Closed	2009	R/W	0	9	1
Pulse Out 2 Wh	1-1 Wh per pulse 2-10 Wh per pulse 3-100 Wh per pulse 4-1000 Wh per pulse 5-10000 Wh per pulse	2010	R/W	0	4	1
Pulse Out 2 Duration	1-10ms 2-25ms 3-50ms 4-100ms 5-250ms 6-500ms	2011	R/W	0	5	1

Communications

Description		Reg.	R/W	Min	Max	Default
Communications Protocol	1-Modbus 2-Bacnet	2012	R/W	0	1	1
Communications Baud Rate	1-9600 2-19200 3-38400 4-57600 5-76800 6-115200	2013	R/W	0	5	2

Description		Reg.	R/W	Min	Max	Default
Communications Parity & Stop	1-Even parity 1 stop bit 2-Odd parity 1 stop 3-No parity 2 stop bits 4-No parity 1 stop bit	2014	R/W	0	3	1
Communications Modbus Address	Modbus client (slave) address	2015	R/W	1	247	247

1. Warning adjusting any of these values via the communications interface will cause the device to apply the setting immediately. Communications parameters of the host will need to change in order to re-establish communications.

Alarms

Description		Reg.	R/W	Min	Max	Default	Scale	Units
Alarm - Voltage Out of Range Enable	1-Disable 2-Enable	2016	R/W	0	1	1	N/A	N/A
Alarm - Voltage Out of Range Nominal	Set nominal L-L voltage for out-of-range alarm, least significant digit is 1/10th of a Volt.	2017	R/W	10	60000	2400	0.1	Volts
Alarm - Voltage Out of Range Threshold	The percent above or below the nominal voltage setting (2017) at which a fault will trigger.	2018	R/W	1	20	10	1	%
Alarm - Current Out of Range Enable	0-Disable 1-Enable	2019	R/W	0	1	0	N/A	N/A
Alarm - Current Out of Range Nominal	Set nominal current for out-of-range alarm, least significant digit is 1/10th of an Amp.	2020	R/W	10	60000	50	0.1	Amps
Alarm - Current Out of Range Threshold	The percent above or below the nominal current setting (2020) at which a fault will trigger.	2021	R/W	1	20	10	1	%
Alarm Ground Current Out of Range Enable	0-Disable 1-Enable	2022	R/W	0	1	0	N/A	N/A
Alarm Ground Current Out of Range Nominal	Set nominal ground current for out-of-range alarm, least significant digit is 1/10th of an Amp.	2023	R/W	10	60000	50	0.1	Amps
Alarm Ground Current Out of	The percent above the nominal ground	2024	R/W	1	20	10	1	%

Description		Reg.	R/W	Min	Max	Default	Scale	Units
Range Threshold	current setting (2023) which a fault will trigger.							
Alarm Frequency Out of Range Enable	0-Disable 1-Enable	2025	R/W	0	1	1	N/A	N/A
Alarm Frequency Out of Range Nominal	Set nominal frequency for out-of-range alarm, least significant digit is 1/100th of a Hertz.	2026	R/W	450	650	600	0.1	Hz
Alarm Frequency Out of Range Threshold	The percent above or below the nominal frequency setting (2026) at which a fault will trigger.	2027	R/W	1	20	10	1	%
Alarm Voltage Phase Loss Enable	0-Disable 1-Enable	2028	R/W	0	1	1	N/A	N/A
Alarm Voltage Phase Loss Threshold	A phase-to-phase comparison of L-N voltages is performed. If any phase's L-N voltage is below the others by the threshold amount, a fault will trigger. Only applicable to 3Φ configurations (ABC or ABCN). Single phase installations will power off during phase loss event.	2029	R/W	1	20	10	1	%
Alarm Voltage Phase Imbalance Enable	0-Disable, 1-Enable	2030	R/W	0	1	1	N/A	N/A
Alarm Voltage Phase Imbalance Threshold	The percent of phase-to-phase imbalance above which a fault will trigger. For a three-phase Y system, both VL-L and VL-N are examined. For a three-phase delta, only VL-L measurements are compared. In a single split-phase, only VL-N are compared.	2031	R/W	1	20	10	1	%

Description		Reg.	R/W	Min	Max	Default	Scale	Units
Alarm Power Factor Low Enable	0-Disable 1-Enable	2032	R/W	0	1	1	N/A	N/A
Alarm Power Factor Low Threshold	Set the (unitless) PF value, below which a fault will trigger.	2033	R/W	1	99	50	0.01	Unitless

Advanced

Description		Reg.	R/W	Min	Max	Default
Reset Wh	Writing 1 will reset all of the stored Wh, VAh and VARh values.	2034	R/W	0	1	0
Count of Wh Resets	Number of times the Wh has been reset.	2035	R	0	65535	0
Reset Run time	Writing 1 will reset the system run time (61 and 62), but not the system power on time (59 and 60).	2036	R/W	0	1	0
Count of run time Resets	Number of times the system run time has been reset.	2037	R	0	65535	0
Reset Pulse Counts	Writing 1 will reset the pulse input counters (63 through 66).	2038	R/W	0	1	0
Firmware Major version	Firmware version number	2039	R	0	255	0
Firmware Minor version	Firmware version number	2040	R	0	255	0
Firmware Patch version	Firmware version number	2041	R	0	255	0
Reboot EMX	Reboots the EMX. When written, this point may not give a response or may return an error due to the reset process. The point will still accept the value.	2042	R/W	0	1	0
Reset Log Content	Writing a 1 value to this register reset all of the stored log entries. This will break communications and display connection for approx. 25 seconds. Do not remove power during this update. When written, this point may not give a response or may return an error due to the reset process. The point will still accept the value.	2043	R/W	0	1	0

Metering Registers

The following table describes each of the power and energy readings provided over Modbus from the device.

R/W:

R = Read Only
R/W = Read and Write

Type, Min, Max:

I16 = INT16	16-bit integer; -32768 to 32767, unless otherwise noted
U16 = UINT16	16-bit unsigned integer; 0 to 65535 (0xFFFF), unless otherwise noted
ENUM = UINT16	16-bit unsigned integer that maps to a defined list of values
U32 = UINT32	32-bit unsigned integer; 0 to 4294967295 (0xFFFFFFFF), unless otherwise noted
U64 = UINT64	64-bit unsigned integer; 0 to 18.466e+18
I64 = INT64	64-bit signed integer; -9.233e+18 to 9.233e+18

Scale:

Values must be multiplied by this scale factor to be read correctly. For some power, current, and voltage readings, the scale factor will be automatically set based on the user settings for voltage and current scale. These multipliers can be read in registers 030-032.

Store:

Values marked "yes" will be stored in non-volatile memory. Stored values will not be lost if the meter experiences a power loss.

Modbus Function Codes:

The EMX metering registers support the following Modbus function codes:

- 0x03 Read Holding Registers
- 0x04 Read Input Register

Some registers span multiple Modbus addresses. Two consecutive registers defined as XXX/YYY indicates a pair of aligned registers, that must be merged into a 32-bit value. Four consecutive registers require merging the results into a 64-bit value.

Description		Reg.	R/W	Min	Max	Scale	Units	Store
V-LN Average		001	R			V-scale	V(rms)	No
V-LL Average		002	R			V-scale	V(rms)	No
Current Average		003	R			I-scale	A(rms)	No
Current Sum		004	R			I-scale	A(rms)	No
Real power total		005	R			P-scale	W	No
Reactive power total		006	R			P-scale	VAR	No
Apparent power total		007	R			P-scale	VA	No
V-LN Phase A		008	R			V-scale	V(rms)	No
V-LN Phase B		009	R			V-scale	V(rms)	No
V-LN Phase C		010	R			V-scale	V(rms)	No
V-LL Phase A-B		011	R			V-scale	V(rms)	No
V-LL Phase B-C		012	R			V-scale	V(rms)	No
V-LL Phase C-A		013	R			V-scale	V(rms)	No
Current Phase A		014	R			I-scale	A(rms)	No
Current Phase B		015	R			I-scale	A(rms)	No
Current Phase C		016	R			I-scale	A(rms)	No
Power Factor Phase A		017	R	-100	100	0.01	NA	No
Power Factor Phase B		018	R	-100	100	0.01	NA	No
Power Factor Phase C		019	R	-100	100	0.01	NA	No
Frequency (Phase A)		020	R	480	620	0.1	Hz	No
Real power Phase A		021	R			P-scale	W	No
Real power Phase B		022	R			P-scale	W	No
Real power Phase C		023	R			P-scale	W	No
Reactive power Phase A		024	R			P-scale	VAR	No
Reactive power Phase B		025	R			P-scale	VAR	No
Reactive power Phase C		026	R			P-scale	VAR	No
Apparent power Phase A		027	R			P-scale	VA	No
Apparent power Phase B		028	R			P-scale	VA	No
Apparent power Phase C		029	R			P-scale	VA	No
Voltage Scale Factor (V-scale)	-3:0.001 -2:0.01 -1:0.1	030	R	-2	2	1	N/A	No
Current Scale Factor (I-scale)	0:1 1:10 2:100 3:1000	031	R	-3	1	1	N/A	No
Power Scale Factor (P-scale)	4:10000 5:100000 6:1000000	032	R	-3	6	1	N/A	No

Description		Reg.	R/W	Min	Max	Scale	Units	Store
Alarm Status Bitfield	Bit 0: Pulse configuration error Bit 1: Pulse overrun error Bit 2: Voltage out of range Bit 3: Current out of range Bit 4: Current sum (ground current) out of range Bit 5: Freq. out of range Bit 6: Voltage phase loss Bit 7: Voltage phase unbalance Bit 8: Power factor low Bit 9 - 15: Reserved	033	R	0	0xFFFF	1	N/A	No
Load Status	0: No load detected 1: Load above threshold	034	R	0	1	1	N/A	No
System power on time		035 036	R	0	4294967295	1	Seconds	No
System run time		037 038	R	0	4294967295	1	Seconds	Yes
Power Reset Count		039 040	R	0	4294967295	1	N/A	Yes
Pulse Count 1		041 042	R	0	4294967295	1	N/A	Yes
Pulse Count 2		043 044	R	0	4294967295	1	N/A	Yes
Real Net Energy total		045 046 047 048	R	0	65535	0.00000001	Wh	Yes
Real Net Energy Phase A		049 050 051 052	R	0	65535	0.00000001	Wh	Yes
Real Net Energy Phase B		053 054 055 056	R	0	65535	0.00000001	Wh	Yes
Real Net Energy Phase C		057 058 059 060	R	0	65535	0.00000001	Wh	Yes
Reactive Net Energy total		061 062 063 064	R	0	65535	0.00000001	VARh	Yes

Description	Reg.	R/W	Min	Max	Scale	Units	Store
Reactive Net Energy Phase A	065 066 067 068	R	0	65535	0.00000001	VARh	Yes
Reactive Net Energy Phase B	069 070 071 072	R	0	65535	0.00000001	VARh	Yes
Reactive Net Energy Phase C	073 074 075 076	R	0	65535	0.00000001	VARh	Yes
Apparent Net Energy total	077 078 079 080	R	0	65535	0.00000001	VAh	Yes
Apparent Net Energy Phase A	081 082 083 084	R	0	65535	0.00000001	VAh	Yes
Apparent Net Energy Phase B	085 086 087 088	R	0	65535	0.00000001	VAh	Yes
Apparent Net Energy Phase C	089 090 091 092	R	0	65535	0.00000001	VAh	Yes
Real Import Energy total	093 094 095 096	R	0	65535	0.00000001	Wh	Yes
Real Import Energy Phase A	097 098 099 100	R	0	65535	0.00000001	Wh	Yes
Real Import Energy Phase B	101 102 103 104	R	0	65535	0.00000001	Wh	Yes
Real Import Energy Phase C	105 106 107 108	R	0	65535	0.00000001	Wh	Yes
Reactive Import Energy total	109 110 111 112	R	0	65535	0.00000001	VARh	Yes
Reactive Import Energy Phase A	113 114 115 116	R	0	65535	0.00000001	VARh	Yes

Description	Reg.	R/W	Min	Max	Scale	Units	Store
Reactive Import Energy Phase B	117 118 119 120	R	0	65535	0.00000001	VARh	Yes
Reactive Import Energy Phase C	121 122 123 124	R	0	65535	0.00000001	VARh	Yes
Apparent Import Energy total	125 126 127 128	R	0	65535	0.00000001	VAh	Yes
Apparent Import Energy Phase A	129 130 131 132	R	0	65535	0.00000001	VAh	Yes
Apparent Import Energy Phase B	133 134 135 136	R	0	65535	0.00000001	VAh	Yes
Apparent Import Energy Phase C	137 138 139 140	R	0	65535	0.00000001	VAh	Yes
Real Export Energy total	141 142 143 144	R	0	65535	0.00000001	Wh	Yes
Real Export Energy Phase A	145 146 147 148	R	0	65535	0.00000001	Wh	Yes
Real Export Energy Phase B	149 150 151 152	R	0	65535	0.00000001	Wh	Yes
Real Export Energy Phase C	153 154 155 156	R	0	65535	0.00000001	Wh	Yes
Reactive Export Energy total	157 158 159 160	R	0	65535	0.00000001	VARh	Yes
Reactive Export Energy Phase A	161 162 163 164	R	0	65535	0.00000001	VARh	Yes
Reactive Export Energy Phase B	165 166 167 168	R	0	65535	0.00000001	VARh	Yes

Description	Reg.	R/W	Min	Max	Scale	Units	Store
Reactive Export Energy Phase C	169 170 171 172	R	0	65535	0.00000001	VARh	Yes
Apparent Export Energy total	173 174 175 176	R	0	65535	0.00000001	VAh	Yes
Apparent Export Energy Phase A	177 178 179 180	R	0	65535	0.00000001	VAh	Yes
Apparent Export Energy Phase B	181 182 183 184	R	0	65535	0.00000001	VAh	Yes
Apparent Export Energy Phase C	185 186 187 188	R	0	65535	0.00000001	VAh	Yes

Real Time Clock Registers

Description		Reg.	R/W	Min	Max	Scale	Units	Store
RTC – Set Year		4000	R/W	2022	2060	1	N/A	No
RTC – Set Month		4001	R/W	1	12	1	N/A	No
RTC – Set Day of Moth		4002	R/W	1	31	1	N/A	No
RTC – Set Day of Week		4003	R/W	0	6	1	N/A	No
RTC – Set Hours		4004	R/W	0	23	1	Hrs	No
RTC – Set Minutes		4005	R/W	0	59	1	Mins	No
RTC – Set Seconds		4006	R/W	0	23	1	Secs	No
RTC – Commit time		4007	R/W	0	1	1	N/A	Yes
RTC - Current Year		4100	R	2022	2060	1	N/A	Yes
RTC - Current Month		4101	R	1	12	1	N/A	Yes
RTC - Current Day of Month		4102	R	1	31	1	N/A	Yes
RTC - Current Day of Week	0 = Sunday 6 = Saturday	4103	R	0	6	1	N/A	Yes
RTC - Current AM/PM Flag, or 0	If in 24-hour mode, will return 0, if in 12 hour mode: 1 = AM, 2 = PM	4104	R	0	2	1	N/A	Yes
RTC - Current Hours		4105	R	0	0	1	Hrs	Yes
RTC - Current Minutes		4106	R	0	0	1	Mins	Yes
RTC - Current Seconds		4107	R	0	0	1	Secs	Yes

Logging Registers

EMX Logging:

Logging on the EMX is only available on models with firmware 2.0 or greater.

Log Source 1 – Log source 12 set the source for the logging. Write the Modbus register 1-188 to the desired source to log that point. If a Modbus register has multiple registers all registers need to be set. For example, if Real Net Energy total is desired to be logged all four registers need to be set.

To trigger a log event Logging – Trigger Source needs to be set to the desired trigger mode, by default it is set to be disabled. Logging can be triggered with the timer, set on Modbus point 5001 in seconds from 15-3600. Triggering can be set over COMMS by writing point 5015 a 1, or Pulse In 1 or 2 can be set to trigger a log whenever a pulse isa detected.

Description		Reg.	R/W	Min	Max	Scale	Units	Store
Logging - Trigger Source	0 = Disabled 1 = Timer 2 = Comms 3 = Pulse In 1 4 = Pulse in 2	5000	R/W	0	3	1	N/A	Yes
Logging - Trigger Interval		5001	R/W	15	3600	1	Secs	Yes
Logging - Mode Select	0 - "Continuous" - continue logging and overwrite old entries, sequentially 1 - "One Shot" - log until EEPROM is full, then stop logging and throw alarm	5002	R/W	0	2	1	N/A	Yes
Logging - Log Source 1		5003	R/W	0	188	1	N/A	Yes
Logging - Log Source 2		5004	R/W	0	188	1	N/A	Yes
Logging - Log Source 3		5005	R/W	0	188	1	N/A	Yes
Logging - Log Source 4		5006	R/W	0	188	1	N/A	Yes
Logging - Log Source 5		5007	R/W	0	188	1	N/A	Yes
Logging - Log Source 6		5008	R/W	0	188	1	N/A	Yes
Logging - Log Source 7		5009	R/W	0	188	1	N/A	Yes
Logging - Log Source 8		5010	R/W	0	188	1	N/A	Yes
Logging - Log Source 9		5011	R/W	0	188	1	N/A	Yes
Logging - Log Source 10		5012	R/W	0	188	1	N/A	Yes
Logging - Log Source 11		5013	R/W	0	188	1	N/A	Yes
Logging - Log Source 12		5014	R/W	0	188	1	N/A	Yes
Logging - Trigger log creation		5015	R/W	0	1	1	N/A	Yes
Logging - Read log at index		5016	R	0	4096	1	N/A	Yes
Logging - Oldest Index		5100	R	0	4096	1	N/A	Yes
Logging - Count of log entries		5101	R	0	4096	1	N/A	Yes
Logging - Current Index		5102	R	0	65535	1	N/A	Yes
Logging - Log data 1		5103	R	0	65535	1	N/A	Yes
Logging - Log data 2		5104	R	0	65535	1	N/A	Yes
Logging - Log data 3		5105	R	0	65535	1	N/A	Yes

Logging - Log data 4	5106	R	0	65535	1	N/A	Yes
Logging - Log data 5	5107	R	0	65535	1	N/A	Yes
Logging - Log data 6	5108	R	0	65535	1	N/A	Yes
Logging - Log data 7	5109	R	0	65535	1	N/A	Yes
Logging - Log data 8	5110	R	0	65535	1	N/A	Yes
Logging - Log data 9	5111	R	0	65535	1	N/A	Yes
Logging - Log data 10	5112	R	0	65535	1	N/A	Yes
Logging - Log data 11	5113	R	0	65535	1	N/A	Yes
Logging - Log data 12	5114	R	0	59	1	N/A	Yes
Logging - Log time stamp seconds	5115	R	0	59	1	N/A	Yes
Logging - Log time stamp minutes	5116	R	0	23	1	N/A	Yes
Logging - Log time stamp hours	5117	R	0	31	1	N/A	Yes
Logging - Log time stamp day of month	5118	R	0	12	1	N/A	Yes
Logging - Log time stamp month	5119	R	0	256	1	N/A	Yes
Logging - Log time stamp year	5120	R	0	65535	1	N/A	Yes
Logging - CRC	5121	R	0	4096	1	N/A	Yes

Modbus Functions

The EMX supports the following functions of the *Modbus Application Protocol Specification*, v1.1b3. Examples are intended to be representative; refer to the full specification for questions or clarification.

Notes:

- The device address defaults to 247 (0xF7).
- EMX device supports Modbus RTU encoding only (not ASCII).
- Refer to the Modbus standard for CRC/LRC calculation procedures.

Data Types

Natively, Modbus holding register functions only support the UINT16 type (2 bytes). The meter constructs additional types from two or more consecutive registers. Client interface software must support the same construction for proper communication:

	# of Registers	Range (hexadecimal)
ENUM	1	0 to specified upper limit
UINT8	1	0 to 255 (0x00FF), unless otherwise noted
UINT16	1	0 to 65535 (0xFFFF), unless otherwise noted
INT16	1	-32768 to -32767 (0xFFFF), unless otherwise noted
BOOL	1	0 to 1
UINT32	2	0 to 4294967295 (0xFFFFFFFF), unless otherwise noted

UINT32 data always occupies two registers (4 bytes) in network byte order (MSB first). Read and write operations should address both registers.

The following examples show UINT32 encodings in a Modbus PDU beginning at byte [n], register [r]:

Value	Decimal	[n]	[n+1]	[n+2]	[n+3]
0xAABBCCDD	2864434397	0xAA	0xBB	0xCC	0xDD
0x01234567	19088743	0x12	0x34	0x56	0x78
0x00010000	65536	0x00	0x01	0x00	0x00
REGISTER		[r]		[r+1]	

0x03 Read Holding Registers

Returns one or more registers in a contiguous block:

	Request	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x03
[2]	Starting Address	2	A = 0 to 65535 (0xFFFF)
[3]	Register Count	2	N = 1 to 125 registers
[4]	CRC	2	

Successful reads return the contents of the requested registers:

	Response	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x03
[2]	Byte Count	1	2 * N
[3]	Register Data	2 * N	
[4]	CRC	2	

Example 1: Read the line frequency of ΦA (026).

Request = **0x** **F7** **03** **00 1A** **00 01** **B1 5B**
[0] [1] [2] [3] [4]

Response = **0x** **F7** **03** **02** **02 59** **B1 0B**
[0] [1] [2] [3] [4]

[3] *Frequency* = 0x0259 = 601 = 60.1 (Hz)

0x04 Read Input Register

Reads one or more read only registers in a contiguous block:

	Request	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x04
[2]	Starting Address	2	A = 0 to 65535 (0xFFFF)
[3]	Register Count	2	N = 1 to 125 registers
[4]	CRC	2	

Successful reads return the contents of the requested registers:

	Response	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x04
[2]	Byte Count	1	2 * N
[3]	Register Data	2 * N	
[4]	CRC	2	

Example 1: Read the line frequency of ΦA (026).

Request = **0x** **F7** **03** **00 1A** **00 01** **B1 5B**
[0] [1] [2] [3] [4]

Response = **0x** **F7** **03** **02** **02 59** **B1 0B**
[0] [1] [2] [3] [4]

[3] *Frequency* = 0x0259 = 601 = 60.1 (Hz)

0x06 Write Single Register

Writes a value to a single register:

	Request	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x06
[2]	Register Address	2	A = 0 to 65535 (0xFFFF)
[3]	Register Value	2	X = 0 to 65535 (0xFFFF)
[4]	CRC	2	

Successful writes echo the original request:

	Response	Size	
[0]	Device Address	1	
[1]	Function Code	1	Always 0x06
[2]	Register Address	2	A
[3]	Register Value	2	X
[4]	CRC	2	

Example 1: Change the phase configuration.

Request = Response = **0x** **F7** **06** **07 D0** **00 01** **5C 11**
[0] [1] [2] [3] [4]

0x10 Write Multiple Registers

Writes one or more registers in a contiguous block:

	Request	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x10
[2]	Starting Address	2	A = 0 to 65535 (0xFFFF)
[3]	Write Count	2	N = 1 to 123 registers
[4]	Byte Count	1	Always 2 * N
[5]	Write Registers	2 * N	X ...
[6]	CRC	2	

Successful writes echo the *Starting Address* and *Write Count*:

	Request	Size	Notes
[0]	Device Address	1	
[1]	Function Code	1	Always 0x10
[2]	Starting Address	2	A
[3]	Write Count	2	N
[4]	CRC	2	

Example 1: Change phase configuration and CT type in one write:

Request = **0x** **F7** **10** **07 D0** **00 02** **04** **00 00 00 01** **04 88**
[0] [1] [2] [3] [4] [5] [6]

Response = **0x** **F7** **10** **07 D0** **00 02** **55 D3**
[0] [1] [2] [3] [4]

MODBUS Exception Codes

When the Modbus interface encounters an error, it will return an exception code. The most common errors are described in the table below. Additional information about exception codes may be found in the reference document.

Reference: https://modbus.org/docs/Modbus_Application_Protocol_V1_1b.pdf

MODBUS Exception Codes		
Code	**Name**	**Meaning**
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the server (or slave). This may be because the function code is only applicable to newer devices and was not implemented in the unit selected. It could also indicate that the server (or slave) is in the wrong state to process a request of this type, for example because it is unconfigured and is being asked to return register values.
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the server (or slave). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, the PDU addresses the first register as 0, and the last one as 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 4, then this request will successfully operate (address-wise at least) on registers 96, 97, 98, 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 5, then this request will fail with Exception Code 0x02 “Illegal Data Address” since it attempts to operate on registers 96, 97, 98, 99 and 100, and there is no register with address 100.
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for server (or slave). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does NOT mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the MODBUS protocol is unaware of the significance of any particular value of any particular register.

Data Type Conversions

The following sections provide information on how to convert from the standard U16 registers that Modbus provides into other formats. Some controllers or Modbus interfaces provide these conversions, in which case the user should utilize those methods, instead of the following conversions.

U16 to I16 Conversion

Conversion from a signed requires checking if the value is value returned (VALUE) is greater than the maximum for a 16-bit integer (32767), if the value is greater than the value 65536 must be subtracted off to calculate a negative value.

If VALUE > 32767

Then: VALUE = VALUE – 65536

Otherwise: VALUE = VALUE (do nothing)

Example:

Reading register 005 (Real power total) the device responds with 64536. This value is greater than 32767, which means it must be adjusted. By subtracting 65536 we get 64536 – 65536 = -1000, which is the correct value for the real power. Please note that in practice a scale value will need to be determined and applied to this output in order to get the value into watts or whatever units are applicable.

U16 to U32 Conversion

Conversion from two unsigned 16-bit registers into a 32-bit value can be done by reading the two necessary registers and multiplying the first (lower register address) register by 32678 and adding the second register.

VALUE = (REGISTER_LOW * 65536) + REGISTER_HIGH

Example:

Reading registers 035 and 036 which together are the system power on time. Register 035 has a value (REGISTER_LOW) of 6, register 036 (REGISTER_HIGH) has a value of 38784. Using the calculation we get (6 * 65536) + 38784 = 432000. This corresponds to the time in seconds that the device has been powered on. 5 Days = 5 * 24 * 60 * 60 = 432000 seconds.

U16 to U64 Conversion

Conversion from 4 unsigned 16-bit registers to a 64-bit register is necessary for using the energy accumulators on the EMX. This is done to maintain system accuracy over long operating durations, and to avoid conditions where the energies appear to cease updating. This follows a similar pattern as the U32 conversion. All four registers must be read, preferably simultaneously with a multi-register read operation. The lowest address register is REG_1, the highest is REG_4.

VALUE = REG_1 * 2^48 + REG_2 * 2^32 + REG_3 * 2^16 + REG_4

Or without the power notation

VALUE = REG_1 * 281,474,976,710,656 + REG_2 * 4,294,967,296 + REG_3 * 65536 + REG_4

Example:

Reading registers 091/092/093/094 which correspond to the Real Import Energy Total (how much energy has been consumed by downstream devices). Register 091 (REG_1) reads 0, register 092 (REG_2) reads 13, register 093 (REG_3) reads 63559 and register 094 (REG_4) reads 22528.

The calculation is 0 * 281,474,976,710,656 + 13 * 4,294,967,296 + 63559 * 65536 + 22528 = 60000000000 when scaled down by the scale of 0.00000001 given in the table it's 600.0 which is the number of Watt Hours of energy that the device has metered at that point.

U16 to I64 Conversion

All of the net energy registers are signed values. A negative sign indicates that net power has been exported, a positive sign indicates that net power has been imported (consumed). To convert from four U16 registers to an I64 register first perform a conversion as described above. Next perform the following step:

If VALUE > (2^63)- 1

Then VALUE = VALUE – 2^64

Otherwise VALUE = VALUE (do nothing).

Appendix D: Hex and ASCII Conversions

HEX	DEC	ASCII
0x00	0	NULL
0x01	1	
0x02	2	
0x03	3	
0x04	4	
0x05	5	
0x06	6	
0x07	7	
0x08	8	
0x09	9	
0x0A	10	
0x0B	11	
0x0C	12	
0x0D	13	
0x0E	14	
0x0F	15	
0x10	16	
0x11	17	
0x12	18	
0x13	19	
0x14	20	
0x15	21	
0x16	22	
0x17	23	
0x18	24	
0x19	25	
0x1A	26	
0x1B	27	
0x1C	28	
0x1D	29	
0x1E	30	
0x1F	31	
0x20	32	
0x21	33	!
0x22	34	"
0x23	35	#
0x24	36	$
0x25	37	%
0x26	38	&
0x27	39	'
0x28	40	(
0x29	41	)
0x2A	42	*
0x2B	43	+
0x2C	44	,
0x2D	45	-
0x2E	46	.
0x2F	47	/
0x30	48	0
0x31	49	1
0x32	50	2
0x33	51	3
0x34	52	4
0x35	53	5
0x36	54	6
0x37	55	7
0x38	56	8
0x39	57	9
0x3A	58	:
0x3B	59	;
0x3C	60	<
0x3D	61	=
0x3E	62	>
0x3F	63	?
HEX	DEC	ASCII
0x40	64	@
0x41	65	A
0x42	66	B
0x43	67	C
0x44	68	D
0x45	69	E
0x46	70	F
0x47	71	G
0x48	72	H
0x49	73	I
0x4A	74	J
0x4B	75	K
0x4C	76	L
0x4D	77	M
0x4E	78	N
0x4F	79	O
0x50	80	P
0x51	81	Q
0x52	82	R
0x53	83	S
0x54	84	T
0x55	85	U
0x56	86	V
0x57	87	W
0x58	88	X
0x59	89	Y
0x5A	90	Z
0x5B	91	[
0x5C	92	\
0x5D	93	]
0x5E	94	^
0x5F	95	_
0x60	96	`
0x61	97	a
0x62	98	b
0x63	99	c
0x64	100	d
0x65	101	e
0x66	102	f
0x67	103	g
0x68	104	h
0x69	105	i
0x6A	106	j
0x6B	107	k
0x6C	108	l
0x6D	109	m
0x6E	110	n
0x6F	111	o
0x70	112	p
0x71	113	q
0x72	114	r
0x73	115	s
0x74	116	t
0x75	117	u
0x76	118	v
0x77	119	w
0x78	120	x
0x79	121	y
0x7A	122	z
0x7B	123	{
0x7C	124	|
0x7D	125	}
0x7E	126	~
0x7F	127	
HEX	DEC	LATIN-1
0x80	128	€
0x81	129	
0x82	130	‚
0x83	131	ƒ
0x84	132	„
0x85	133	…
0x86	134	†
0x87	135	‡
0x88	136	ˆ
0x89	137	‰
0x8A	138	Š
0x8B	139	‹
0x8C	140	Œ
0x8D	141	
0x8E	142	Ž
0x8F	143	
0x90	144	
0x91	145	‘
0x92	146	’
0x93	147	“
0x94	148	”
0x95	149	•
0x96	150	–
0x97	151	—
0x98	152	˜
0x99	153	™
0x9A	154	š
0x9B	155	›
0x9C	156	œ
0x9D	157	
0x9E	158	ž
0x9F	159	Ÿ
0xA0	160	
0xA1	161	¡
0xA2	162	¢
0xA3	163	£
0xA4	164	¤
0xA5	165	¥
0xA6	166	¦
0xA7	167	§
0xA8	168	¨
0xA9	169	©
0xAA	170	ª
0xAB	171	«
0xAC	172	¬
0xAD	173	-
0xAE	174	®
0xAF	175	¯
0xB0	176	°
0xB1	177	±
0xB2	178	²
0xB3	179	³
0xB4	180	´
0xB5	181	µ
0xB6	182	¶
0xB7	183	·
0xB8	184	¸
0xB9	185	¹
0xBA	186	º
0xBB	187	»
0xBC	188	¼
0xBD	189	½
0xBE	190	¾
0xBF	191	¿
HEX	DEC	LATIN-1
0xC0	192	À
0xC1	193	Á
0xC2	194	Â
0xC3	195	Ã
0xC4	196	Ä
0xC5	197	Å
0xC6	198	Æ
0xC7	199	Ç
0xC8	200	È
0xC9	201	É
0xCA	202	Ê
0xCB	203	Ë
0xCC	204	Ì
0xCD	205	Í
0xCE	206	Î
0xCF	207	Ï
0xD0	208	Ð
0xD1	209	Ñ
0xD2	210	Ò
0xD3	211	Ó
0xD4	212	Ô
0xD5	213	Õ
0xD6	214	Ö
0xD7	215	×
0xD8	216	Ø
0xD9	217	Ù
0xDA	218	Ú
0xDB	219	Û
0xDC	220	Ü
0xDD	221	Ý
0xDE	222	Þ
0xDF	223	ß
0xE0	224	à
0xE1	225	á
0xE2	226	â
0xE3	227	ã
0xE4	228	ä
0xE5	229	å
0xE6	230	æ
0xE7	231	ç
0xE8	232	è
0xE9	233	é
0xEA	234	ê
0xEB	235	ë
0xEC	236	ì
0xED	237	í
0xEE	238	î
0xEF	239	ï
0xF0	240	ð
0xF1	241	ñ
0xF2	242	ò
0xF3	243	ó
0xF4	244	ô
0xF5	245	õ
0xF6	246	ö
0xF7	247	÷
0xF8	248	ø
0xF9	249	ù
0xFA	250	ú
0xFB	251	û
0xFC	252	ü
0xFD	253	ý
0xFE	254	þ
0xFF	255	ÿ