

**Title:** Using XL-Series Data Loggers in Modbus Networks

**Description:** This document describes how to retrieve data from and send data to XL-series data loggers over a Modbus network.

**Product:** H-350XL™, H-500XL™, H-510XL™, H-522XL™, H-522+™

**Author:** Kevin Goodsell

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# 1 General Information

## 1.1 Introduction

As of firmware version 2.02, an XL-series data logger can function as a slave (also known as a server) in a Modbus network. When used in this way, the data logger can respond to Modbus requests by reporting back data values for any source that can normally be logged or transmitted. In order to prevent long delays in responding, some sources can optionally be queried for the “last known” value (usually the value at the last scan). Alternatively, a new value can be retrieved and sent with the response; however, in some cases this can cause a very long delay before the response is set. In cases where the time to retrieve a new value is known to be very short, a current value is always used.

Certain options can also be set by writing to Modbus registers.

## 1.2 Modbus Support

### 1.2.1 Supported Modes of Operation

An XL-series data logger can operate in either the Modbus RTU mode or the Modbus ASCII mode. Supported baud rates are 1200, 2400, 4800, 9600, and 19200. Parity can be set to Even, Odd, or None. In compliance with the Modbus specification, when parity is set to None, an extra stop bit is inserted. In RTU mode, 8 data bits are used. In ASCII mode, 7 data bits are used.

### 1.2.2 Supported Functions

The XL-series data loggers support the following Modbus functions:

<i>Function Name</i>	<i>Function Code</i>
Read Coils	1 (0x01)
Read Holding Registers	3 (0x03)
Read Input Registers	4 (0x04)
Write Single Coil	5 (0x05)
Write Single Register	6 (0x06)
Write Multiple Coils	15 (0x0F)
Write Multiple Registers	16 (0x10)

## 2 Configuration

### 2.1 Hardware Interface

The data logger communicates on the Modbus network using the RS-232 port labeled **RS-232 3**.

## 2.2 Configuration Options

Modbus configuration options can be found under **Output Options -> Modbus Options** in the front-panel display menus. These options are also available through the terminal command and menu modes, but for simplicity this document will focus on the display menus. See Appendix B: Terminal Menus and Commands for details about accessing these settings from the terminal command and menu systems. Please note that the H-522XL does not include a front-panel display, so one of the terminal interfaces must be used.

The following sections describe the options for configuring Modbus behavior.

### 2.2.1 Modbus Mode

The **Modbus Mode** option is used to enable or disable Modbus operation, and also to select between the RTU and ASCII Modbus modes. The options are **Off**, **RTU**, and **ASCII**.

Because port **RS-232 3** is also used for other functions (Remote Display, Auto Print, ALERT radios), setting the Modbus mode to **Off** when it is not being used is recommended in order to prevent conflicts.

### 2.2.2 Modbus Address

The **Modbus Address** option is used to set the slave address that the data logger will use on the Modbus network. Values from 1 to 247 can be used. The data logger will only respond to messages sent to this address.

### 2.2.3 Modbus Baud

The **Modbus Baud** option is used to set the communication baud rate. The options are **19200**, **9600**, **4800**, **2400**, and **1200**.

Note that other functions that use port **RS-232 3** do not respect the Modbus baud rate.

### 2.2.4 Modbus Parity

The **Modbus Parity** option is used to select what type of parity to use for serial communication. The options are **None**, **Even**, and **Odd**. When **None** is selected, an extra stop bit is transmitted instead of a parity bit.

### 2.2.5 Modbus TimeOut

The **Modbus TimeOut** option is used to select how long (in seconds) the data logger should stay on when no messages are being received. When this time expires the data logger enters a low power mode (unless something else prevents this, such as the front panel display being turned on). While in the low power mode, activity on the Modbus network will cause the data logger to turn back on. However, there is a short delay before it is fully on and able receive Modbus messages again. This will result in lost messages, so retransmissions may be required in this case.

Using a value of 0 for the timeout places the data logger in an “always on” mode. This prevents lost messages due to the wake delay, but it also prevents the logger from using its low power mode, resulting in higher power consumption.

## 3 Data Formats and Addressing

### 3.1 General Notes

Most registers are grouped into pairs to create 32-bit values. Similar data can be retrieved from different addresses, with the choice of address determining the format of the data and (in some cases) whether the value should be measured prior to returning the result, or whether the last known value should be returned instead. The following table describes these options.

<i>Address</i>	<i>Data Format</i>	<i>New or Last Known Value</i>
0 to 249	32-bit IEEE single-precision floating point	Last Known
250 to 499	32-bit signed integer, calculated by multiplying the value by 1000 then rounding to the nearest integer.	Last Known
500 to 749	32-bit IEEE single-precision floating point	New
750 to 999	32-bit signed integer, calculated by multiplying the value by 1000 then rounding to the nearest integer.	New
1000 and up	Currently unused.	

There are a few exceptions. First, some sources are known to update very quickly, and therefore a new value is always used. Second, the time and date fields each occupy a single register and are not replicated at any other address.

Appendix A: Address Maps is provided as a quick reference for locating addresses.

### 3.2 Coils

Only coil addresses 0 through 2 are valid. Addresses 0 and 1 correspond to the two digital I/O ports on the XL-series data loggers. They can always be queried for the current state of the ports. They can also be set using the Write Single Coil or Write Multiple Coils functions (function codes 5 and 15, respectively); however, this operation is only valid when the port being set is configured for Triggered Continuous Output or Auto Continuous Output mode. A request to set a port that is configured for a different mode will result in exception 4 (Slave Device Failure).

Coil address 2 corresponds to the switchable 12 volt excitation. This can always be queried for the current state, and it can also be written under certain circumstances. In order for a write to succeed, the XL series data logger must be revision N or newer, since the 12 volt excitation on earlier revisions was not switchable. Also, the 12 volt excitation must be set to either the **Dflt. On** or **Dflt. Off** (on by default or off by default) mode. If the write fails for any of these reasons, exception 4 (Slave Device Failure) is returned.

### 3.3 Input Registers

Input registers are used for data sources other than functions, date, time, and digital inputs. This includes things like SDI-12 sensors, analog inputs, event counts, and system information such as battery voltage.

### 3.4 Holding Registers

Holding registers are used for time, date, and XL functions. Time and date are unusual because each field occupies only a single register. Addresses 0 through 5 correspond to the current year (2 digits only), month, day of the month, hour (using a 24-hour clock), minute, and second, in that order. The current date and time can be set by writing to these registers.

Writing all the time and date registers simultaneously is recommended to prevent errors resulting from the time (and possibly the date) unexpectedly updating just before the write takes effect. For example, suppose the clock is to be set back 2 seconds. The current time is 5:32:59. The current seconds value is read, 2 is subtracted, and 57 is written back to the seconds register. However, before this write takes place, the clock updates to 5:33:00. After the write, the clock reads 5:33:57 instead of the intended time of 5:32:57.

XL functions are also represented as holding registers. XL functions support reading both the most recently calculated value and a newly calculated value, and writing a new value. Writing a value completely replaces the previous function with a single constant value. This is useful if an application requires the XL-series data logger to log values supplied over the Modbus interface.

When writing a new value to an XL function, the full 32-bit (2 register) value must be written. Writes that only cover one 16-bit register will result in an error. There is no such restriction on reading.

## Appendix A: Address Maps

### Coil addresses

<i>Source</i>	<i>Coil Address</i>	<i>Notes</i>
Digital I/O 1	0 (1)	Always readable, only writable when configured for Continuous Output (Triggered or Auto).
Digital I/O 2	1 (2)	
+12 Volt Excitation	2 (3)	Only writable on revision N (or newer) data loggers, and only when 12 volt excitation mode is Default On or Default Off.

### Input Register Addresses

<i>Source</i>	<i>Stale Float</i>	<i>Stale Int</i>	<i>Fresh Float</i>	<i>Fresh Int</i>	<i>Notes</i>
Stage	0 (30001)	250 (30251)	500 (30501)	750 (30751)	1
PSI	2 (30003)	252 (30253)	502 (30503)	752 (30753)	2
PtTemp	4 (30005)	254 (30255)	504 (30505)	754 (30755)	2
RemStg	6 (30007)	256 (30257)	506 (30507)	756 (30757)	

<i>Source</i>	<i>Stale Float</i>	<i>Stale Int</i>	<i>Fresh Float</i>	<i>Fresh Int</i>	<i>Notes</i>
Counts	8 (30009)	258 (30259)	508 (30509)	758 (30759)	3
TotCnt	10 (30011)	260 (30261)	510 (30511)	760 (30761)	3
CtRate	12 (30013)	262 (30263)	512 (30513)	762 (30763)	3
Ana1	14 (30015)	264 (30265)	514 (30515)	764 (30765)	
Ana2	16 (30017)	266 (30267)	516 (30517)	766 (30767)	
Ana3	18 (30019)	268 (30269)	518 (30519)	768 (30769)	
Ana4	20 (30021)	270 (30271)	520 (30521)	770 (30771)	
Freq	22 (30023)	272 (30273)	522 (30523)	772 (30773)	
Encodr	24 (30025)	274 (30275)	524 (30525)	774 (30775)	3
Batt	26 (30027)	276 (30277)	526 (30527)	776 (30777)	3
TScans	28 (30029)	278 (30279)	528 (30529)	778 (30779)	3
Basic1	30 (30031)	280 (30281)	530 (30531)	780 (30781)	
Basic2	32 (30033)	282 (30283)	532 (30533)	782 (30783)	
Basic3	34 (30035)	284 (30285)	534 (30535)	784 (30785)	
Basic4	36 (30037)	286 (30287)	536 (30537)	786 (30787)	
Basic5	38 (30039)	288 (30289)	538 (30539)	788 (30789)	
SDI01	70 (30071)	320 (30321)	570 (30571)	820 (30821)	
SDI02	72 (30073)	322 (30323)	572 (30573)	822 (30823)	
SDI03	74 (30075)	324 (30325)	574 (30575)	824 (30825)	
SDI04	76 (30077)	326 (30327)	576 (30577)	826 (30827)	
SDI05	78 (30079)	328 (30329)	578 (30579)	828 (30829)	
SDI06	80 (30081)	330 (30331)	580 (30581)	830 (30831)	
SDI07	82 (30083)	332 (30333)	582 (30583)	832 (30833)	
SDI08	84 (30085)	334 (30335)	584 (30585)	834 (30835)	
SDI09	86 (30087)	336 (30337)	586 (30587)	836 (30837)	
SDI11	88 (30089)	338 (30339)	588 (30589)	838 (30839)	
SDI12	90 (30091)	340 (30341)	590 (30591)	840 (30841)	
SDI13	92 (30093)	342 (30343)	592 (30593)	842 (30843)	
SDI14	94 (30095)	344 (30345)	594 (30595)	844 (30845)	
SDI15	96 (30097)	346 (30347)	596 (30597)	846 (30847)	
SDI16	98 (30099)	348 (30349)	598 (30599)	848 (30849)	
SDI17	100 (30101)	350 (30351)	600 (30601)	850 (30851)	
SDI18	102 (30103)	352 (30353)	602 (30603)	852 (30853)	
SDI19	104 (30105)	354 (30355)	604 (30605)	854 (30855)	
SDI21	106 (30107)	356 (30357)	606 (30607)	856 (30857)	
SDI22	108 (30109)	358 (30359)	608 (30609)	858 (30859)	
SDI23	110 (30111)	360 (30361)	610 (30611)	860 (30861)	
SDI24	112 (30113)	362 (30363)	612 (30613)	862 (30863)	
SDI25	114 (30115)	364 (30365)	614 (30615)	864 (30865)	
SDI26	116 (30117)	366 (30367)	616 (30617)	866 (30867)	

<i>Source</i>	<i>Stale Float</i>	<i>Stale Int</i>	<i>Fresh Float</i>	<i>Fresh Int</i>	<i>Notes</i>
SDI27	118 (30119)	368 (30369)	618 (30619)	868 (30869)	
SDI28	120 (30121)	370 (30371)	620 (30621)	870 (30871)	
SDI29	122 (30123)	372 (30373)	622 (30623)	872 (30873)	
SDI31	124 (30125)	374 (30375)	624 (30625)	874 (30875)	
SDI32	126 (30127)	376 (30377)	626 (30627)	876 (30877)	
SDI33	128 (30129)	378 (30379)	628 (30629)	878 (30879)	
SDI34	130 (30131)	380 (30381)	630 (30631)	880 (30881)	
SDI35	132 (30133)	382 (30383)	632 (30633)	882 (30883)	
SDI36	134 (30135)	384 (30385)	634 (30635)	884 (30885)	
SDI37	136 (30137)	386 (30387)	636 (30637)	886 (30887)	
SDI38	138 (30139)	388 (30389)	638 (30639)	888 (30889)	
SDI39	140 (30141)	390 (30391)	640 (30641)	890 (30891)	
SDI41	142 (30143)	392 (30393)	642 (30643)	892 (30893)	
SDI42	144 (30145)	394 (30395)	644 (30645)	894 (30895)	
SDI43	146 (30147)	396 (30397)	646 (30647)	896 (30897)	
SDI44	148 (30149)	398 (30399)	648 (30649)	898 (30899)	
SDI45	150 (30151)	400 (30401)	650 (30651)	900 (30901)	
SDI46	152 (30153)	402 (30403)	652 (30653)	902 (30903)	
SDI47	154 (30155)	404 (30405)	654 (30655)	904 (30905)	
SDI48	156 (30157)	406 (30407)	656 (30657)	906 (30907)	
SDI49	158 (30159)	408 (30409)	658 (30659)	908 (30909)	
SDI51	160 (30161)	410 (30411)	660 (30661)	910 (30911)	
SDI52	162 (30163)	412 (30413)	662 (30663)	912 (30913)	
SDI53	164 (30165)	414 (30415)	664 (30665)	914 (30915)	
SDI54	166 (30167)	416 (30417)	666 (30667)	916 (30917)	
SDI55	168 (30169)	418 (30419)	668 (30669)	918 (30919)	
SDI56	170 (30171)	420 (30421)	670 (30671)	920 (30921)	
SDI57	172 (30173)	422 (30423)	672 (30673)	922 (30923)	
SDI58	174 (30175)	424 (30425)	674 (30675)	924 (30925)	
SDI59	176 (30177)	426 (30427)	676 (30677)	926 (30927)	
SDI61	178 (30179)	428 (30429)	678 (30679)	928 (30929)	
SDI62	180 (30181)	430 (30431)	680 (30681)	930 (30931)	
SDI63	182 (30183)	432 (30433)	682 (30683)	932 (30933)	
SDI64	184 (30185)	434 (30435)	684 (30685)	934 (30935)	
SDI65	186 (30187)	436 (30437)	686 (30687)	936 (30937)	
SDI66	188 (30189)	438 (30439)	688 (30689)	938 (30939)	
SDI67	190 (30191)	440 (30441)	690 (30691)	940 (30941)	
SDI68	192 (30193)	442 (30443)	692 (30693)	942 (30943)	
SDI69	194 (30195)	444 (30445)	694 (30695)	944 (30945)	
SDI71	196 (30197)	446 (30447)	696 (30697)	946 (30947)	

<i>Source</i>	<i>Stale Float</i>	<i>Stale Int</i>	<i>Fresh Float</i>	<i>Fresh Int</i>	<i>Notes</i>
SDI72	198 (30199)	448 (30449)	698 (30699)	948 (30949)	
SDI73	200 (30201)	450 (30451)	700 (30701)	950 (30951)	
SDI74	202 (30203)	452 (30453)	702 (30703)	952 (30953)	
SDI75	204 (30205)	454 (30455)	704 (30705)	954 (30955)	
SDI76	206 (30207)	456 (30457)	706 (30707)	956 (30957)	
SDI77	208 (30209)	458 (30459)	708 (30709)	958 (30959)	
SDI78	210 (30211)	460 (30461)	710 (30711)	960 (30961)	
SDI79	212 (30213)	462 (30463)	712 (30713)	962 (30963)	
SDI81	214 (30215)	464 (30465)	714 (30715)	964 (30965)	
SDI82	216 (30217)	466 (30467)	716 (30717)	966 (30967)	
SDI83	218 (30219)	468 (30469)	718 (30719)	968 (30969)	
SDI84	220 (30221)	470 (30471)	720 (30721)	970 (30971)	
SDI85	222 (30223)	472 (30473)	722 (30723)	972 (30973)	
SDI86	224 (30225)	474 (30475)	724 (30725)	974 (30975)	
SDI87	226 (30227)	476 (30477)	726 (30727)	976 (30977)	
SDI88	228 (30229)	478 (30479)	728 (30729)	978 (30979)	
SDI89	230 (30231)	480 (30481)	730 (30731)	980 (30981)	
SDI91	232 (30233)	482 (30483)	732 (30733)	982 (30983)	
SDI92	234 (30235)	484 (30485)	734 (30735)	984 (30985)	
SDI93	236 (30237)	486 (30487)	736 (30737)	986 (30987)	
SDI94	238 (30239)	488 (30489)	738 (30739)	988 (30989)	
SDI95	240 (30241)	490 (30491)	740 (30741)	990 (30991)	
SDI96	242 (30243)	492 (30493)	742 (30743)	992 (30993)	
SDI97	244 (30245)	494 (30495)	744 (30745)	994 (30995)	
SDI98	246 (30247)	496 (30497)	746 (30747)	996 (30997)	
SDI99	248 (30249)	498 (30499)	748 (30749)	998 (30999)	

Notes:

1. Only available on the H-350XL and H-510XL.
2. Only available on the H-350XL.
3. Value is always updated, even for a stale read. Stale and fresh addresses are equivalent.

### ***Holding Register Addresses***

The following holding registers are 16-bit integers, rather than the usual 32-bit values.

<i>Source</i>	<i>Address</i>	<i>Notes</i>
Year	0 (40001)	Years are stored as two digits. When writing, other digits are stripped off.
Month	1 (40002)	
Day of Month	2 (40003)	

<i>Source</i>	<i>Address</i>	<i>Notes</i>
Hour	3 (40004)	Based on a 24-hour clock.
Minute	4 (40005)	
Second	5 (40006)	

The following holding registers can only be written as 32-bit values.

<i>Source</i>	<i>Stale Float</i>	<i>Stale Int</i>	<i>Fresh Float</i>	<i>Fresh Int</i>
FNT01	100 (40101)	350 (40351)	600 (40601)	850 (40851)
FNT02	102 (40103)	352 (40353)	602 (40603)	852 (40853)
FNT03	104 (40105)	354 (40355)	604 (40605)	854 (40855)
FNT04	106 (40107)	356 (40357)	606 (40607)	856 (40857)
FNT05	108 (40109)	358 (40359)	608 (40609)	858 (40859)
FNT06	110 (40111)	360 (40361)	610 (40611)	860 (40861)
FNT07	112 (40113)	362 (40363)	612 (40613)	862 (40863)
FNT08	114 (40115)	364 (40365)	614 (40615)	864 (40865)
FNT09	116 (40117)	366 (40367)	616 (40617)	866 (40867)
FNT10	118 (40119)	368 (40369)	618 (40619)	868 (40869)
FNT11	120 (40121)	370 (40371)	620 (40621)	870 (40871)
FNT12	122 (40123)	372 (40373)	622 (40623)	872 (40873)
FNT13	124 (40125)	374 (40375)	624 (40625)	874 (40875)
FNT14	126 (40127)	376 (40377)	626 (40627)	876 (40877)
FNT15	128 (40129)	378 (40379)	628 (40629)	878 (40879)
FNT16	130 (40131)	380 (40381)	630 (40631)	880 (40881)
FNT17	132 (40133)	382 (40383)	632 (40633)	882 (40883)
FNT18	134 (40135)	384 (40385)	634 (40635)	884 (40885)
FNT19	136 (40137)	386 (40387)	636 (40637)	886 (40887)
FNT20	138 (40139)	388 (40389)	638 (40639)	888 (40889)
FNT21	140 (40141)	390 (40391)	640 (40641)	890 (40891)
FNT22	142 (40143)	392 (40393)	642 (40643)	892 (40893)
FNT23	144 (40145)	394 (40395)	644 (40645)	894 (40895)
FNT24	146 (40147)	396 (40397)	646 (40647)	896 (40897)
FNT25	148 (40149)	398 (40399)	648 (40649)	898 (40899)
FNT26	150 (40151)	400 (40401)	650 (40651)	900 (40901)
FNT27	152 (40153)	402 (40403)	652 (40653)	902 (40903)
FNT28	154 (40155)	404 (40405)	654 (40655)	904 (40905)
FNT29	156 (40157)	406 (40407)	656 (40657)	906 (40907)
FNT30	158 (40159)	408 (40409)	658 (40659)	908 (40909)
FNT31	160 (40161)	410 (40411)	660 (40661)	910 (40911)
FNT32	162 (40163)	412 (40413)	662 (40663)	912 (40913)
FNT33	164 (40165)	414 (40415)	664 (40665)	914 (40915)
FNT34	166 (40167)	416 (40417)	666 (40667)	916 (40917)

<i>Source</i>	<i>Stale Float</i>	<i>Stale Int</i>	<i>Fresh Float</i>	<i>Fresh Int</i>
FNT35	168 (40169)	418 (40419)	668 (40669)	918 (40919)
FNT36	170 (40171)	420 (40421)	670 (40671)	920 (40921)
FNT37	172 (40173)	422 (40423)	672 (40673)	922 (40923)
FNT38	174 (40175)	424 (40425)	674 (40675)	924 (40925)
FNT39	176 (40177)	426 (40427)	676 (40677)	926 (40927)
FNT40	178 (40179)	428 (40429)	678 (40679)	928 (40929)

## Appendix B: Terminal Menus and Commands

This appendix describes how to configure Modbus options using the Menu and Command modes that are available through a terminal connected to the port labeled **RS-232 1**.

### Menus

The Modbus settings are located under the **Output Options** menu, in the **Modbus Out Options** sub-menu. These menu items are nearly identical to those found in the front panel display menus.

### Commands

The terminal commands that correspond to menu options used in this Application Note are described in the following table. Commands should be immediately followed by a question mark to print the current setting, or immediately followed by an equals sign and a new value to change the setting.

<i>Menu Option</i>	<i>Command</i>
<b>Modbus Mode</b>	<b>MODBUSMODE</b>
<b>Modbus Address</b>	<b>MODBUSADDRESS</b>
<b>Modbus Baud</b>	<b>MODBUSBAUDRATE</b>
<b>Modbus Parity</b>	<b>MODBUSPARITY</b>
<b>Modbus TimeOut</b>	<b>MODBUSTIMEOUT</b>