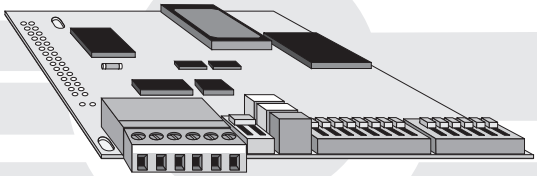
MILLTRONICS

SMARTLINX INTERFACE MODULE
FOR MODBUS RTU

Instruction Manual PL-578 January 2001



SmartLinx™

33455780
Rev. 1.2

SMARTLINX INTERFACE MODULE

Safety Guidelines

Warning notices must be observed to ensure personal safety as well as that of others, and to protect the product and the connected equipment. These warning notices are accompanied by a clarification of the level of caution to be observed.

Qualified Personnel

This device/system may only be set up and operated in conjunction with this manual. Qualified personnel are only authorized to install and operate this equipment in accordance with established safety practices and standards.

Warning: This product can only function properly and safely if it is correctly transported, stored, installed, set up, operated, and maintained.

Note: Always use product in accordance with specifications.

Contact SMPI Technical Publications at the following address:

Technical Publications
Siemens Milltronics Process Instruments Inc.
1954 Technology Drive, P.O. Box 4225
Peterborough, Ontario, Canada, K9J 7B1
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Specifications

Application:

- compatible with Modbus RTU masters that use function codes 03, 06, 16

Compatible Instruments:

- AiRanger XPL Plus
- AiRanger DPL Plus
- AiRanger SPL
- CraneRanger
- InterRanger DPS 300

Communication Settings

- baud rate: ○ 1200, 2400, 4800, 9600, 19200, 38400 bps
- parity: ○ none, odd or even
- stop bit: ○ 1 or 2
- data bits: ○ 8
- hardware flow control: ○ none

Connection:

- 6-position screw terminal

Termination:

- RS-485 switch selectable, open or 110 Ω internal

Cable:

- for RS-232 connection use cable consistent with the RS-232 standard
- for RS-485 connection use cable consistent with the RS-485 standard
- (see Wiring Guidelines on page 35 for more suggestions)

About this Manual

This manual is intended to provide the user with the information required to successfully install and connect a Milltronics SmartLinx™ Modbus RTU module and set it up for communication within a Modbus RTU network.

This manual is targeted to a technical audience in the industrial communications field with a sound working knowledge of Modbus RTU.

Modbus RTU is an industry standard protocol owned by Schneider Automation Inc.[1] and is used throughout process control industries for communication between instruments, such as manufactured by Milltronics, and controllers, such as PLCs and PCs.

A brief description of Modbus RTU is given in this manual. For a full description of the Modbus RTU protocol, contact Groupe Schneider or visit their website at *www.modicon.com*.

Note:
Milltronics does not own the Modbus RTU protocol. All information regarding that protocol is subject to change without notice.

[1] Modicon is a registered trademark of Groupe Schneider.

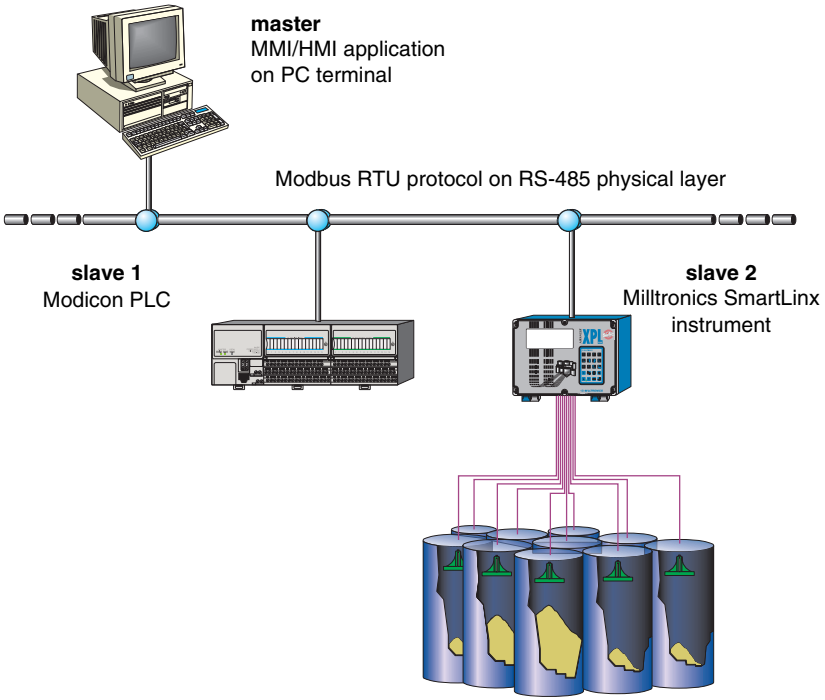
About this Module

The Milltronics SmartLinx™ Modbus RTU Module plugs into a compatible Milltronics instrument to allow connection to any Modbus RTU master controller.

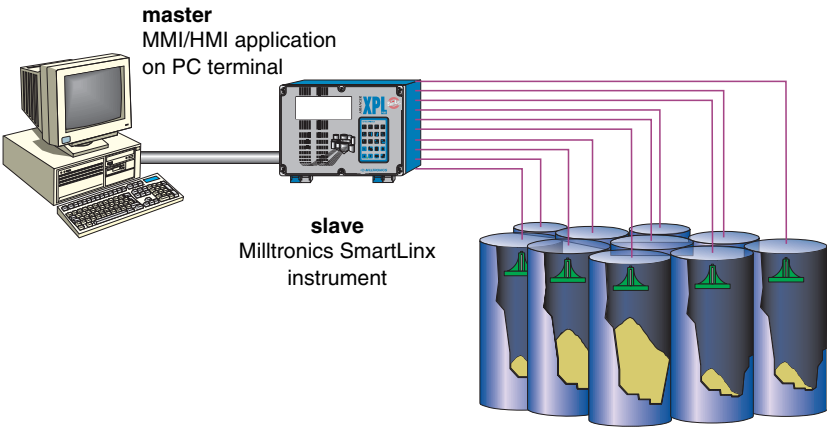
Modbus RTU is an industry standard protocol that is supported by many different instruments. A brief description of the protocol and the Milltronics memory map are outlined in Modbus RTU Protocol section of this manual (see page 20).

Only those instruments which support the SmartLinx™ Modbus RTU module can use this card. See Specifications on page 5 for a list of compatible instruments.

Typical Modbus RTU RS-485 System



Typical Modbus RTU RS-232 System



Installation

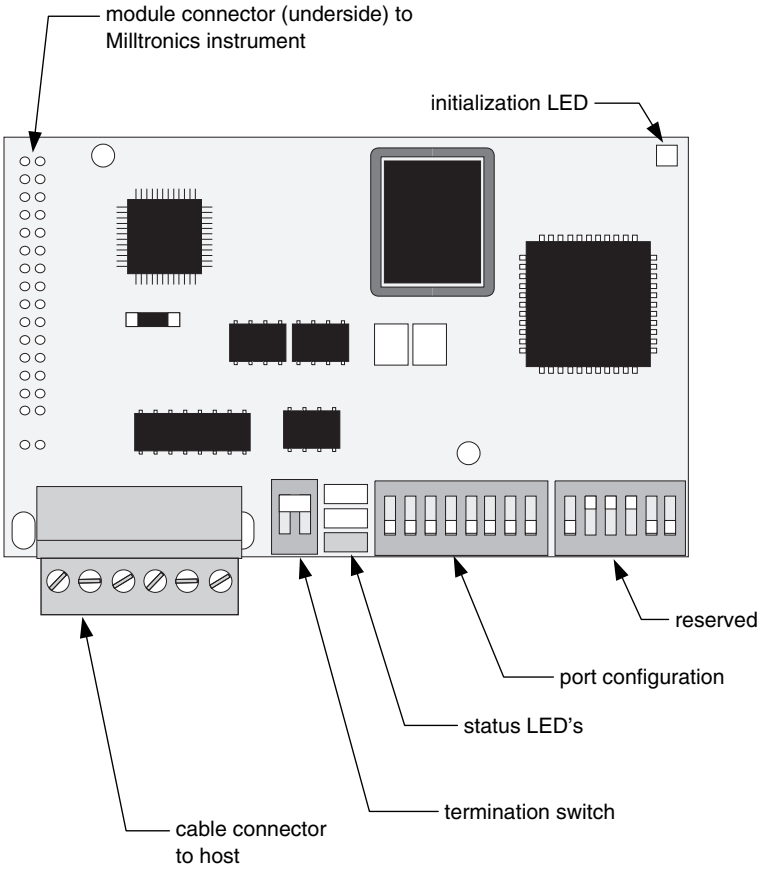
The SmartLinx™ module may have been shipped installed in your unit, or separately for onsite installation. Refer to the manual for the Milltronics SmartLinx™ instrument for details on module location and physical installation.

Compatibility

AiRanger Series

- AiRanger XPL Plus
- AiRanger DPL Plus
- AiRanger SPL
- CraneRanger
- InterRanger DPS 300

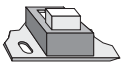
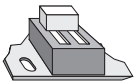
Module Outline



Termination Switch

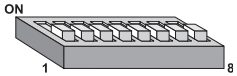
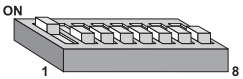
Termination is generally of concern when communicating at higher baud rates, and when the Milltronics host instrument is the unique or terminating slave.

If the 110 Ω switched termination is inappropriate, set the switch to open and connect an appropriate resistor across terminals 4 and 5.

termination	setting	
open	off	
110 Ω	on	

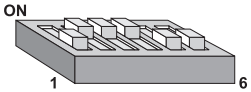
Port Configuration

Switch one configures the port for either RS-232 or RS-485 transmission.

transmission	dip switches
RS-232	
RS-485	

Reserved Switch

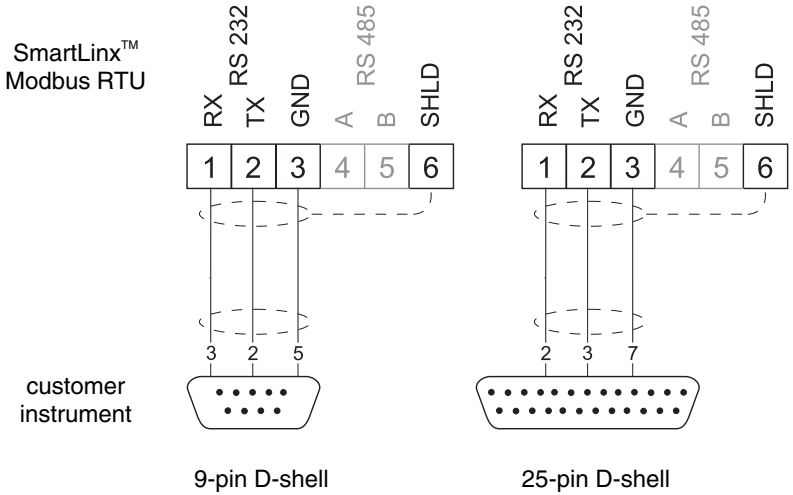
These switches are reserved and must be left in their factory setting.



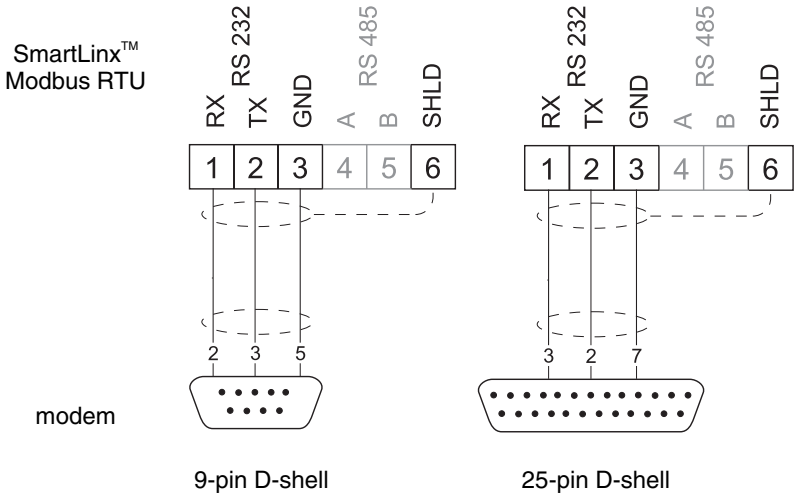
Cable Connection

Note:
No hardware flow control is used.

RS-232 Connection PC Connection

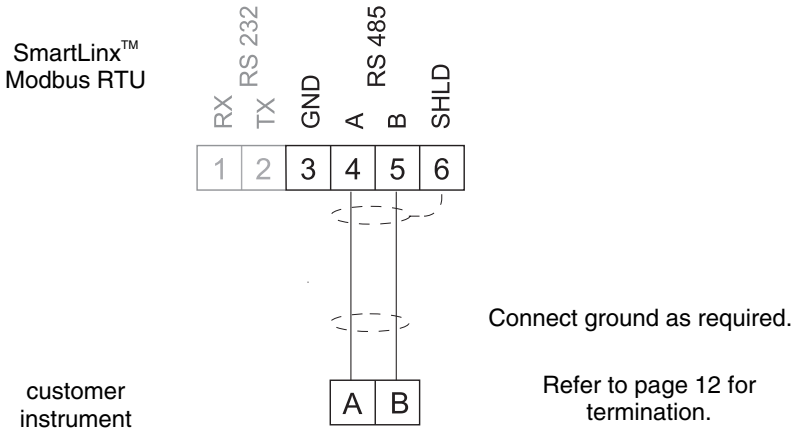


RS-232 Connect to Modem



Note:
When using a modem, set the value of P758 to 15. See page 18.

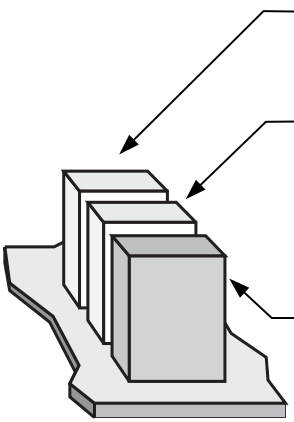
RS-485 Connection



Operation

Communication on the Modbus RTU network is indicated by four SmartLinx™ LED's. Three of the LED's are grouped together at the bottom centre of the module and the other is located on the upper right of the module.

Status LED's



Green LED

- blinks as the module is initialized
- remains ON to indicate module is ready

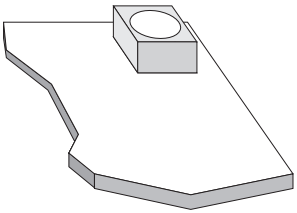
Green LED

- blinks as the module is initialized
- turns ON when the first Modbus RTU command is received
- flickers as additional Modbus RTU commands are received

Red LED

- blinks as the module is initialized
- indicates module failure (replace module):
  - flashes 4 times per second to indicate a DPRAM fault
  - flashes 2 times per second to indicate a ROM fault
  - flashes once per second to indicate a RAM fault

Initialization LED



LED

- blinks orange as the module is initialized
- flashes green during normal operation

Communications Setup

General

The following parameters must be defined in the Milltronics instrument to establish successful communication. Instructions on how to set these parameters are found in the associated instrument manual.

Notes:

- *f* denotes factory setting.
- The SmartLinx™ module only supports 8 data bits, and no hardware flow control.
- For odd or even parity, use 1 stop bit. For no parity, use two stop bits (as per Modbus RTU specification).

Specific Parameters

P751 Baud Rate

Sets the baud rate according to the table:

0 = 1200 bps
1 = 2400 bps
2 = 4800 bps
3 = 9600 bps
4 = 19200 bps *f*
5 = 38400 bps

P752 Parity Mode

Sets the parity mode according to the table:

0 = no parity *f*
1 = odd parity
2 = even parity

P753 Slave Address

Sets the slave address. Valid address range is 1 to 247 (factory setting is 1).

P758 Interframe Spacing

The silent time expected, in milliseconds, between two adjacent data packets.

Note:
When a modem is being used, set this parameter to a value of 15. See page 13 for more information on configuring a modem.

A value of zero “0” selects the traditional 3 and half characters (recommended) as the time interval that separates one command from the next.

Any value from 1 to 32 specifies the time in milliseconds. A value of 33 specifies the highest possible value of 32.678 ms.

Values:
0 to 33
Preset: 0

Application Layer

Modbus RTU is an industry standard protocol owned by Schneider Automation Inc.[2] and is used throughout process control industries for communication between instruments. Modbus RTU is a master-slave type protocol. An instrument with a SmartLinx™ Modbus RTU is a slave unit.

SmartLinx™ Modbus RTU only supports the RTU mode of Modbus, and *not* ASCII.

A brief description of Modbus RTU is given in this manual. For a full description of the Modbus RTU protocol, contact Groupe Schneider, or see the Modicon web site (www.modicon.com).

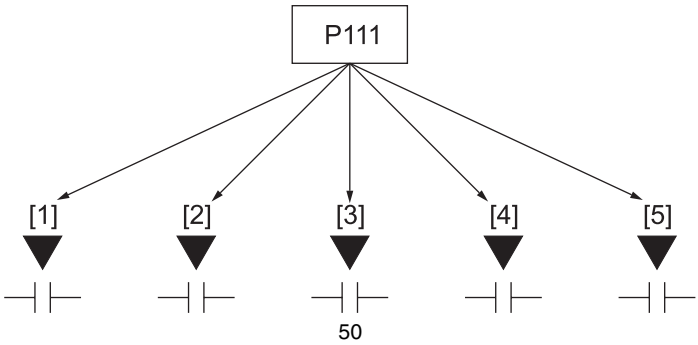
Note:
Milltronics does not own the Modbus RTU protocol. All information regarding that protocol is subject to change without notice.

Parameter Indexes

Most parameters used on Milltronics SmartLinx™ instruments are indexed. Indexing allows a parameter to relate to more than one input or output. For example, some parameters are indexed by measurement point while others are indexed by relay or discrete input.

An index that relates to an input or output is called a Primary Index.

Example of a primary index:
P111[3] = 50 (Relay Control Function for relay 3 = 50, pump control)



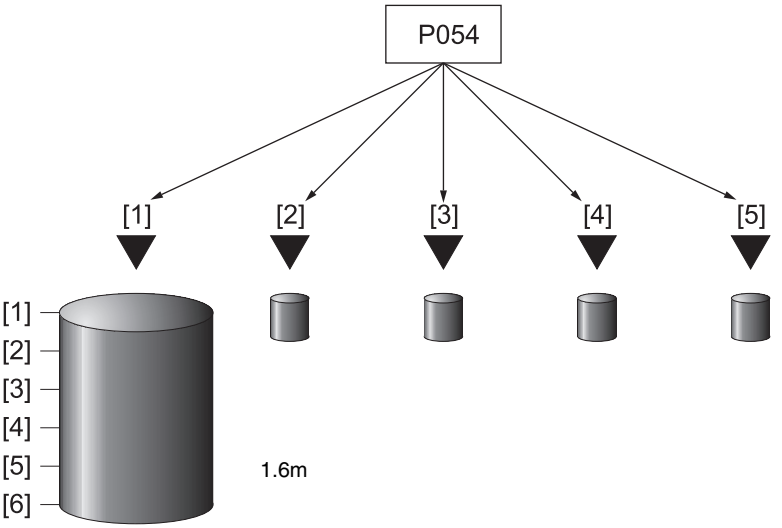
Sometimes a parameter requires a second index to allow for multiple values on an indexed input or output. For example a measurement point which calculates a reading on volume can require characterization breakpoints.

[2] Modicon is a registered trademark of Groupe Schneider.

These breakpoints are given on a secondary index (the primary index relates to the transducer input).

An index that relates to a previously indexed parameter is called a secondary index.

Examples of secondary indexes are:
P054[1,5] = P054 (Breakpoint Levels) for breakpoint 5 on transducer 1 = 1.6m



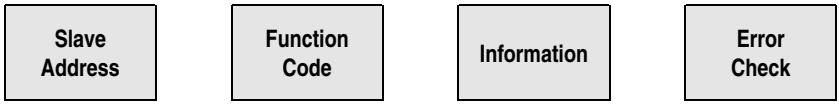
The way that indexes are handled in the memory map depends on the data access method used.

How Modbus RTU Works

As mentioned previously, Modbus RTU is a master-slave type protocol. This is also sometimes referred to as a query-response protocol. What both of these terms mean is that on the network, there is one master which requests information from the slave instruments. This is done using a “function code” which indicates the information or the action being requested. The slave instruments are not permitted to talk unless they have been asked for information. When responding, the slave will either give the information that the master has requested or send back an error code which would either say why it cannot give the information or that it did not understand the request.

Modbus RTU was designed for communication between PLCs and sensing instruments. Therefore the protocol makes reference to inputs, outputs, coils, registers, and forcing. For our purposes, everything has been mapped into holding registers so that Modbus RTU function code 03 can read them and Modbus RTU function codes 06 and 16 can write to them.

To give you a better idea of how a Modbus RTU message works, a master on network would send a message in a format similar to this:



Where:

Slave Address	the network address (P753) of the slave you are talking to.
Function Code	number that represents a Modbus RTU command. As described above, SmartLinx™ supports function codes 03, 06, and 16.
Information	register data, depending on the function code.
Error Check	cyclical redundancy check (CRC).

There is more to the frame than is described above, this is shown to give the user a general idea of what is going on. For a full description, please refer to the Modbus RTU specifications.

Register Mapping

SmartLinx™ Modbus RTU only works with the compatible Milltronics SmartLinx™ instruments (see page 5). These instruments range from one to 10 points of measurement. As such, this manual covers the maximum 10 point measurement capability. If your instrument has fewer than 10 points, ignore data in registers associated to non-existing points of measurement. These registers are present but they contain undefined values.

Note:
Parameter P999 (Master Reset) is not accessible via the SmartLinx™ interface.

Data Access Methods

Modbus master units may be PLCs, PCs or DCS controllers. By issuing appropriate commands, a controller can access data in three different ways.

Note:
The design of the SmartLinx™ module requires that a maximum delay of 0.1 seconds between the time that the master writes a value to the time that it can read the response. Insure that the master device takes this delay into account.

Direct Access

Common values are mapped directly into registers.

Multiple Parameter Access (MPA)

This is a hand-shaking method where the Modbus RTU master requests the parameter number, secondary index, decimal place, and format, then the SmartLinx™ module writes all 10 primary indexes of that parameter into the mapped registers. The PLC can then read these values. (Recall that in Milltronics products, the memory is arranged as parameter number, primary index, secondary index).

Note:
MPA values are only updated in Run mode.

Using Multiple Parameter Access (MPA)

Words 40032 through 40035 are used for MPA, allowing continuous monitoring in words 40022 through 40031 of selected parameters for points 1 to 10. Using these words does not allow the changing of parameter values.

1. Write the values into words 40032 through 40035 that define the requested information.

2. Monitor the address variables. When the values returned match those that were written, go to step 3.

3. Read the requested values in words 40022 through 40031. These values are continuously updated. Continue reading from these words until new values are required. At that time, go back to step 1.

Single Parameter Access (SPA).

This is a hand-shaking method where the PLC requests the parameter number, primary index, secondary index, decimal place, format, read/write flag, and value, then the SmartLinx™ module either reads or writes the value. With this method any value in the Milltronics product can be read or written.

Using Single Parameter Access (SPA)

Words 40036 through 40043 are used for SPA, allowing continuous monitoring or demand programming of a parameter for a given indexed measurement point, individually selected for each point.

Reading a Parameter

1. After setting word 40043 to 0, “read”, write the required parameter information to words 40038 through 40042.

2. Monitor the address variables that are reflected back. When the values returned match those that were written, go to step 3.

3. Read the requested value from word 40036. This value is continuously updated. Continue reading from this word until a new value is required. At that time, go back to step 1.

Writing a Parameter

1. Write the required parameter information to words 40038 through 40042, the new value in word 40037 and set word 40043 to 1, “write”.

2. Monitor the address variables. When the values returned match those that were written, your write is proceeding.

3. Read the value in word 40036 to confirm that the correct value has been written.

4. Set word 40043 back to 0 “read”.

Note:
Parameters should only be written in Program mode. Ensure word 40044 = 1.

Register Map – Level Products

Registers	Description	Access	Data Type
40001	point status (read only)	direct	bitmapped
40002 to 40011	point reading (read only)		integer
40012 to 40021	point alarm and status (read only)		bitmapped
40022 to 40031	returned values (read only)	MPA	integer
40032	parameter number		integer
40033	secondary index		integer
40034	decimal place		integer
40035	format		integer
40036	current value (read only)	SPA	integer
40037	new value		integer
40038	parameter number		integer
40039	secondary Index		integer
40040	primary Index		integer
40041	decimal place		integer
40042	format		0/1
40043	write flag		0/1
40044	operating mode	direct	0/1
40045	point on priority		bitmapped

R40001: Point Status (read only)

bit	Description
00 to 09:	**Point Status** Indicates the operation of the points 1 to 10.

bit	09	08	07	06	05	04	03	02	01	00
point	10	9	8	7	6	5	4	3	2	1

If a bit status is 0, the corresponding point is deemed to be operational based on the criteria defined by R40012 to R40021, bits 01 to 04. If the bit status is 1, then the corresponding point is deemed non-operational. To further diagnose a point's operation, examine the corresponding point alarm and status R40012 to R40021.

If a bit status is 1, then for the corresponding point alarm word, one or more of the alarm bits 01 to 04 are also 1 to indicate the operational problem.

10:	**Operating Mode** 0 = instrument in 'run' mode 1 = instrument in 'program' mode
11 to 15:	**Reserved** These bits are undefined.

R40002 to R40011: Point Reading (read only)

These words contain the value of parameter P920 (Reading) for points 1 to 10, respectively. The reading is expressed as a percent of full scale, multiplied by 100, giving a range of -20,000 to 20,000 which corresponds to –200.00% to 200.00%. Refer to the Milltronics' instrument documentation for a definition of 'P920'.

Note that these values may contain numeric level data for inoperative or malfunctioning points; refer to R40001 point status, and R40012 to R40021 point alarm and status for the actual operational status of the measurement points.

R40012 to R40021: Point Alarm and Status (read only)

These words contain the corresponding alarm and status bits for point 1 to 10. So R40012 = measurement point 1 and R40021 = measurement point 10.

Bit status:
0 = false
1 = true

bit	description
00	point not in operation
01	point failsafe timer expired
02	point failed (cable shorted, open, or transceiver problem)
03	point temperature sensor failed
04 to 12	reserved for future use
13	level emptying
14	level filling
15	scan mode priority

R40022-R40031: Returned Values, MPA (read only)

These words contain values requested by writing to R40032 to R40035. The type of data and format are specified with that request (see below). In this, the index number 1 to 10, corresponds to R40022 to R40031. So R40022 = measurement point 1 and R40031 = measurement point 10.

R40032: Parameter Number, MPA

Specifies the parameter number for the returned value in R40022 to R40031.

R40033: Parameter Secondary Index, MPA

Specifies the parameter index for the value returned in R40022 to R40031. This word is ignored for parameters which don't use indexes.

Some specific Milltronics instrument parameters use indices to address the multiple values stored within the single parameter. See Parameter Indexes on page 19 for details.

Note:
The primary index is implicit in the word location where register 40022 = index 1 and register 40031 = index 10.

R40034: Decimal Place, MPA

Specifies the number of decimal places that the returned values are shifted. This affects words R40022 to R40031.

Positive values indicate that the decimal place shifts to the left.

i.e. A 1 means that all returned values have the decimal place shifted 1 space to the left and a returned value of 5,213 is interpreted as 521.3.

Negative values indicate that the decimal place shifts to the right.

i.e. for example if this word is -1, a returned value of 5,213 is interpreted as 52,130.

R40035: Format, MPA

This word sets the format for the returned values.

Values:
0 = normal
1 = percent of span

R40036: Current Value, SPA (read only)

This word is the current value of the parameter specified in the SPA area R40038 to R40042.

R40037: New Value, SPA

This is the new value for the parameter specified in R40038 to R40042. To verify the write check that R40036 returns the value that was written here.

Word R40043 must be set to “1” to enable the write.

R40038: Parameter Number, SPA

Specifies the parameter number.

R40039: Parameter Secondary Index, SPA

Specifies the secondary index for the parameter specified by R40038. This word is ignored for parameters which do not use multiple indexes. See Parameter Indexes on page 19 for details.

R40040: Parameter Primary Index, SPA

Specifies the primary index number for the parameter specified by R40038. See Parameter Indexes on page 19 for details.

R40041: Decimal Place, SPA

Specifies the number of decimal places that the returned values are shifted. This affects words R40037 and R40036.

Positive values indicate that the decimal place shifts to the left.

i.e. A 1 means that all returned values have the decimal place shifted 1 space to the left and a returned value of 5,213 is interpreted as 521.3.

Negative values indicate that the decimal place shifts to the right.

i.e. for example if this word is -1, a returned value of 5,213 is interpreted as 52,130.

R40042: Format, SPA

This word sets the format for the value in R40036, R40037.

Values:
0 = normal
1 = percent of span

R40043: Read / Write Flag, SPA

This word determines whether the master system is reading a value from R40036 or writing a value to R40037. It is good practice to confirm the write by reading current value R40036 and then reset this register to zero.

Values:
0 = read parameter value in R40036
1 = continually write new value to R40037 until reset to 0

R40044: Operating Mode

This word sets the operating mode of the Milltronics SmartLinx™ instrument. The instrument changes mode only when the status of the bit changes.

The operating mode is also set via the instrument keypad.

Bit status
0 = run mode
1 = program mode

R40045: Point-on-Priority

Bits 00 to 09 set the priority status of corresponding points 1 to 10.

bit	09	08	07	06	05	04	03	02	01	00
point	10	9	8	7	6	5	4	3	2	1

Bit status
0 = normal
1 = priority

e.g.

bit	09	08	07	06	05	04	03	02	01	00
status	0	0	0	0	0	0	0	1	0	1

…shows that measurement points 3 and 1 are on priority scan

All other bits are reserved and should contain 0.

If this word is used to control point-on-priority, then the Milltronics instrument must be configured to permit this. Parameter P720 must be set to 1 (manual, BIC-II or SmartLinx™) for each point to permit priority control for that point. To enable priority control for all points, store '1' to parameter P720, point '0'.

Data Types

The Milltronics instrument parameters take on many values in various formats, as discussed in the Milltronics SmartLinx™ instrument manual. For the convenience of the programmer, those values are converted to and from 16-bit integer numbers, since those are easily handled by most PLCs.

Integer

Integer parameter values are by far the most common. For example, parameter P920 (Reading), returns a number representing the current reading (either level or volume, depending on the Milltronics SmartLinx™ instrument configuration).

Numeric values may be requested or set in either units or percent of span, and may be specified with a number of decimal places.

Numeric values must be in the range -20,000 to be +20,000 to be valid. If a parameter is requested and its value is more than +20,000, the number 32,767 is returned; if it is less than -20,000, the number -32,768 is returned. If this happens, increase the number of decimal places for that parameter.

If a parameter cannot be expressed in terms of percent (e.g. span), or has no meaningful value, the special number 22,222 is returned. Try requesting the parameter in units, or refer to the Milltronics host instrument manual to understand the format and use of the requested parameter.

Bit Values

Bits are packed into registers in groups of 16 bits (1 word). In this manual we number the bits from 0 to 15, with bit 0 being the least significant bit and bit 15 referring to the most significant bit.

15	14	13	12	11	10	09	08	07	06	05	04	03	02	01	00
MSB															LSB

Split Values

Certain parameters are actually a pair of numbers separated by a colon, in the format xx:yy.

One example is P807, Transducer Noise, where:
xx = the average noise value in dB.
yy = the peak noise in dB.

The number which corresponds to xx:yy, either for reading or setting a parameter, is determined by the following formula:

For storing to the Milltronics instrument:
value = (xx + 128) x 256 + (yy + 128)

For reading from the Milltronics instrument:
xx = (value / 256) – 128
yy = (value % 256) – 128

Where:
% is the modulus operator.
The modulus can be computed by following these steps:
$value_1$ = value / 256
$value_2$ = remainder of value1
$value_3$ = $value_2$ x 256
yy = $value_3$ - 128

It may simplify programming to notice:
xx = (most significant byte of value) – 128
yy = (least significant byte of value) – 128

Text Messages

Note:
Used for Level products only.

If a Milltronics instrument parameter returns a text message, that message is converted to an integer and provided in the register. The numbers are shown in the table below:

Number	Text Message as displayed on LCD
22222	invalid value
30000	off
30001	on
30002	≡ ≡ ≡ ≡
30003	[ ]]] (parameter does not exist)
30004	err
30005	err1
30006	open
30007	shrt
30008	pass
30009	fail
30010	hold
30011	lo
30012	hi
30013	de
30014	en
30015	- - - - (parameter has not been set)
-32768	value is less than -20,000
32767	value is greater than 20,000

Relay Function Codes (P111 Only)

Note:
Used for Level products only.

If a Milltronics instrument parameter returns a relay function code, that message is converted to a number and provided in the register. The numbers are shown in the table below:

Relay Function Code	Number	P111 =
Off, relay not used	0	0
Undesignated Level Alarm	1	1
Low-Low Level Alarm	2	1 – LL
Low Level Alarm	3	1 – L
High Level Alarm	4	1 – H
High-High Level Alarm	5	1 – HH
In Bounds Alarm	6	2
In Bounds Alarm	7	2 – b1
In Bounds Alarm	8	2 – b2
Out of Bounds Alarm	9	3
Out of Bounds Alarm	10	3 – b1
Out of Bounds Alarm	11	3 – b2
Rate of Level Change Alarm	12	4
Rate of Level Change Alarm	13	4 – r1
Rate of Level Change Alarm	14	4 – r2
Temperature Alarm	15	5
Loss of Echo (LOE) Alarm	20	6
Transducer Cable Fault Alarm	16	7
Non-sequenced Pump Control	25	50
unknown function	200	

Note:
See the manual for the host instrument for full information on P111.

Modbus RTU Error Codes

With the memory map shown in Register Map – Level Products on page 24, if the user tries to write to a read only register, no error code will be generated and the value will be ignored. If the user tries to access an invalid parameter to write a read only parameter by using MPA or SPA, then no error code will be generated and for the read, a value of some sort will be returned, for a write, the value will be ignored.

If the host used an unsupported function code, undocumented results may occur. The error should be “01” but this is not guaranteed. The host should not do this.

Troubleshooting

Generally

In all cases, first check that the SmartLinx™ Modbus RTU Module has passed its on-going built-in self test (instrument parameter P790). The result should be PASS.

If FAIL is indicated, either the module is defective, or the module connector on the Milltronics instrument is defective.

If 'ERR1' is indicated, the Milltronics software doesn't recognize the ID number of the installed module. Please contact Milltronics or your distributor for instructions and/or upgraded Milltronics SmartLinx™ compatible instrument software.

Specifically

Q1: I tried to set a Milltronics instrument parameter using a SPA write, but the parameter remains unchanged.

A1.1: Some parameters can only be changed when the Milltronics instrument isn't scanning. Try putting the Milltronics instrument in program mode, using operating mode R40044.

A1.2: Try setting the parameter from the keypad. If it can't be set using the keypad, check the lock parameter (P000).

Q2: I have communications, but periodically the Modbus master gets a series of Modbus time out errors, and the red LED on the SmartLinx™ module comes on.

A2.1: Check the configuration of the SmartLinx™ module and if you are using no parity (P752), then verify that the Modbus master is set for two stop bits.

A.2.2: Consult your Milltronics representative.

Q3: I've connected using RS-485 and checked all the communications parameters and wiring, and I'm still not getting communication.

A.3.1 Check to make sure that the RS-485 A line at the Milltronics SmarLinx™ instrument is connected to the A line at the master, and that the B line is connected to the B line.

Wiring Guidelines

The improper wiring and improper chose of cables is one of the most common sources of communication problems. Listed below are some comments that should help:

- Length (maximum):
  - 15 meters (50 feet) for RS-232
  - 1200 meters (4000 feet) for RS-485
- make sure that communication cable is run separately from power and control cables (i.e. do not tie wrap your RS-232 cable to the 120 V ac power cable or have them in the same conduit)
- cable is shielded, and the cable should be connected to ground at one end of the cable only
- 24 AWG (minimum)
- follow proper grounding guidelines for all instruments on the LAN
- use good quality, communication grade (shielded, twisted pairs) cable that is recommended for the RS standard that you are using

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MILLTRONICS

Siemens Milltronics Process Instruments Inc.
1954 Technology Drive, P.O. Box 4225
Peterborough, ON. Canada K9J 7B1
Tel: (705) 745-2431 Fax: (705) 741-0466
www.milltronics.com

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