MicroManager

MODBUS® SLAVE I/O EXPANSION MODULE

Instruction Manual
MM3010-MBS

CAROTRON

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D.C. DRIVES, A.C. INVERTERS,
SOLID STATE STARTERS, SYSTEM INTERFACE
CIRCUITS AND ENGINEERED SYSTEMS

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1 General Description

The MicroManager 3010 series is a microprocessor based Modbus® RTU I/O expansion module. Model MM3010-MBS (Modbus® Slave) is designed for use in industrial SCADA (Serial Control And Data Acquisition) applications. It provides analog and digital I/O that can be accessed/controlled over an RS485 Modbus® RTU network.

2 Specifications

2.1 Electrical

Power Requirements
- 18-36 VDC, .5 Amps max
- Nominal 24VDC
- Fused internally

Power Supply Output
- +10V regulated supply: 10mA max.
- -10V regulated supply: 10mA max.
- +12V regulated supply: 50mA max.

Digital Inputs (4 Total)
- Sinking or Sourcing Logic (selectable)
- Sinking Mode
  - Vil=+20.0VDC max
  - Vih=0.0VDC min to +17.0VDCmax
- Sourcing Mode
  - Vil=+5.0VDC max
  - Vih=+8.0VDC min to +30.0VDCmax

Voltage Inputs (4 Total)
- 13 bit resolution
- Voltage Range: -10VDC to +10 VDC
- Input Impedance: 220kΩ

Current Inputs (2 Total)
- 10 bit resolution
- Range: 0 to 20mA, 4 to 20mA
- Input Impedance: 250Ω

Frequency/Counter Inputs (2 Total)
- Frequency: 42kHz max, square wave
- 32 bit counters
- Voltage: +15VDC max
  Vil=0.0VDC min to +1.1VDC max
  Vih=+3.0VDC min to +15.0VDC max

Relay Outputs (4 Total)
- Form C contacts
- 2A @115VAC
- 2A @60VDC

Analog Outputs (4 Total)
- 2 dedicated voltage
- 2 current/voltage
- 12 bit resolution
- Voltage: 0 to ±10VDC
- Current: 0 to 20mADC (max load 400Ω)

Communications Ports (2 Total)
- Modbus® RTU Slave
- RS485 Multidrop (2 or 4 wire)
- Primary Port: Terminals
- Secondary Port: Modular

Default Communications Input
- Vil(max)=0.5VDC
- Vih(min)=2.0VDC

Temperature Range
- Chassis: 0-55ºC

2.2 Physical

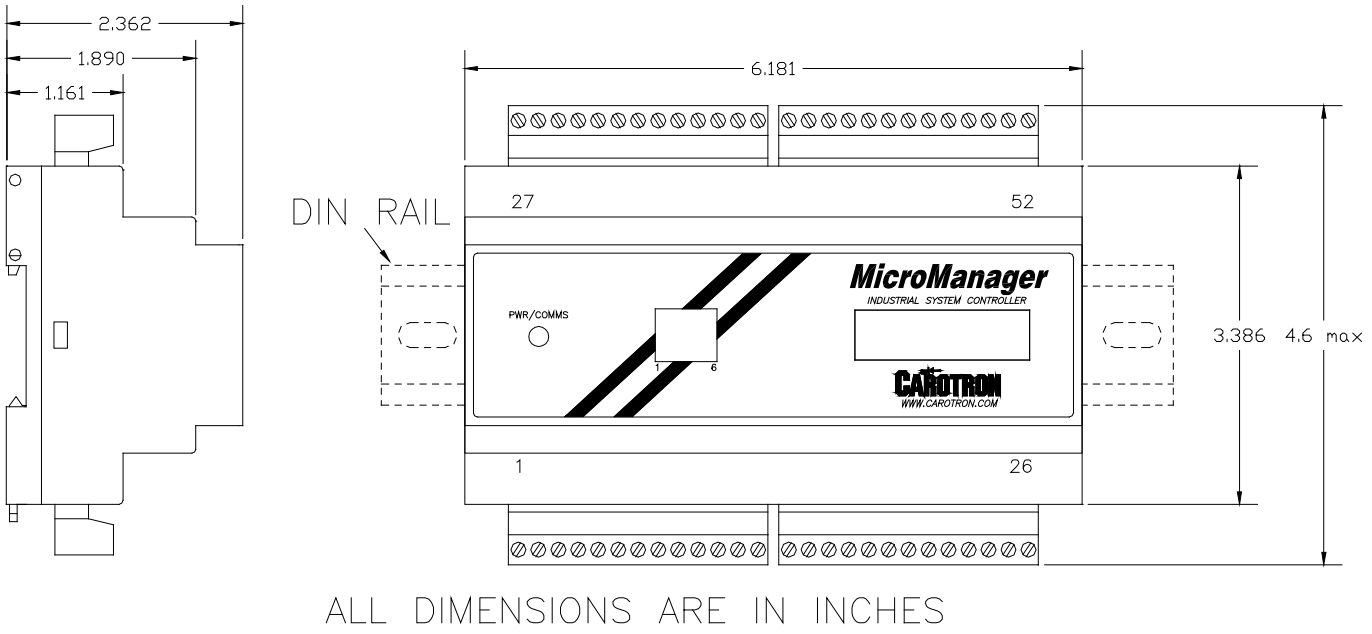


Figure 1: Physical Dimensions

3 Installation

3.1 Wiring Guidelines

To prevent electrical interference and to minimize start-up problems, adhere to the following guidelines:

Use fully insulated and shielded cable for all signal wiring. The shield should be connected to circuit common at one end only. The other end of the shield should be clipped and insulated to prevent the possibility of accidental grounding.

Signal level wiring such as listed above should be routed separately from high level wiring such as armature, field, operator control and relay control wiring. When these two types of wire must cross, they should cross at right angles to each other.

Any relay, contactor, starter, solenoid or other electro-mechanical device located in close proximity to or on the same line supply as the MicroManager should have a transient suppression device such as an MOV or R-C snubber connected in parallel with its coil. The suppressor should have short leads and be connected as close to the coil as possible.

4 Terminal Connections

4.1 Signal Connections

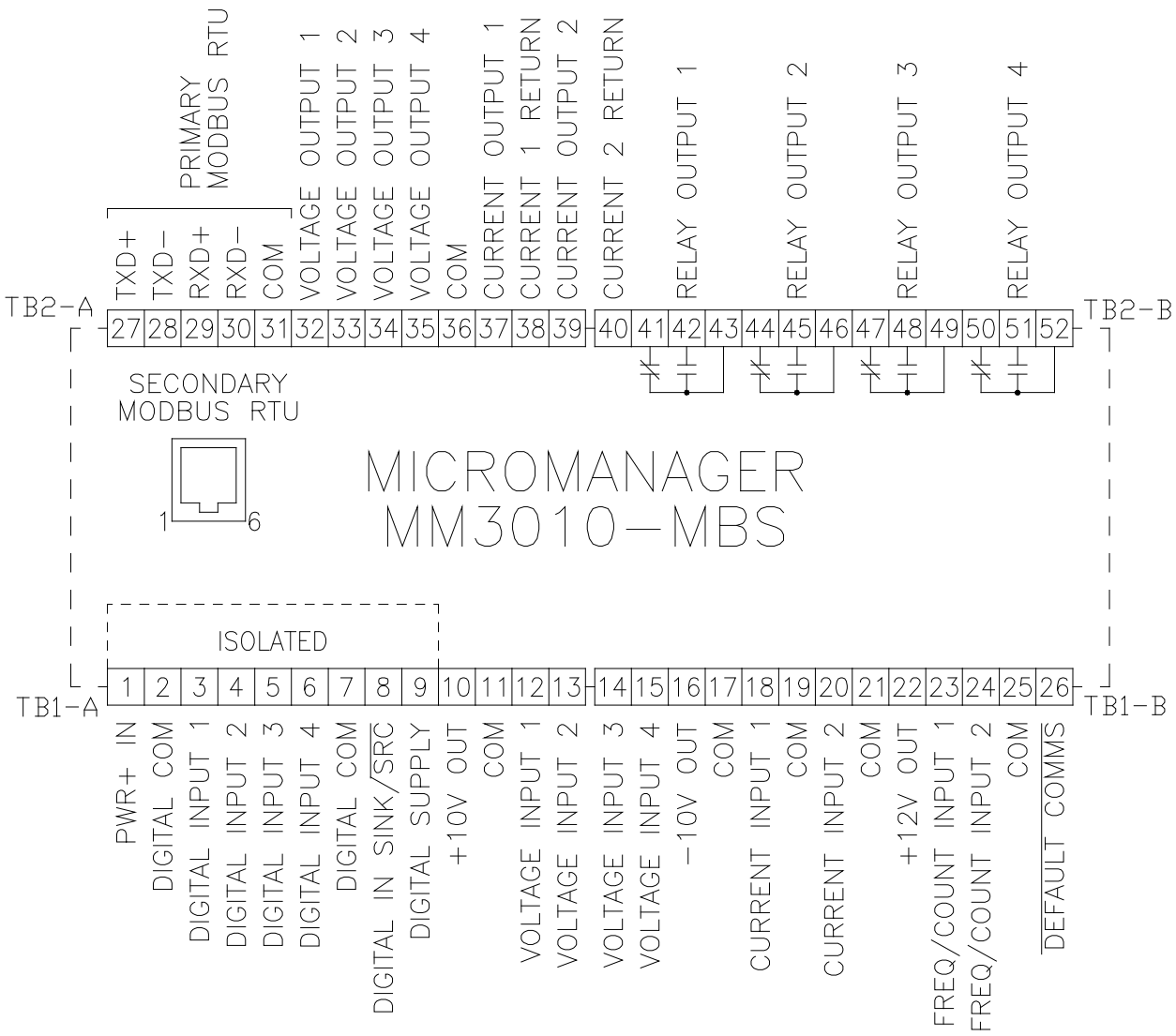


Figure 2: General Connections

5 Parameters

Model MM3010-MBS provides two Modbus RS485 slave ports. The main port (located on the terminals) is typically used to connect to the primary Modbus network. The modular port is typically used for setup and monitoring with a PC.

WARNING! The RS485 ports are NOT isolated from the I/O circuitry on the unit. If the MM3010-XXX is connected to any non-isolated industrial equipment, damage to network devices (such as PCs, HMIs, etc…) may occur. An RS485 isolator must be used in these circumstances to prevent damage. Please consult Carotron for additional information.

Setup and configuration is accomplished by using Carotron's MicroLink software. A serial port is required on a PC to connect to the MM3010-MBS. If a serial port is not available, a USB to Serial Adapter can be used.

Connect the PC to the MM3010-MBS by using the included cable (P/N CLT2000-A01). Start the MicroLink software. The MicroLink's communication settings must match those of the MM3010-MBS. The default settings are:

Baud Rate: 38400
Stop Bits: 2
Parity: None
Modbus Address: 1

If the MM3010-MBS secondary port's settings are unknown or in doubt, the unit can be forced to use the default communication settings by connecting the Default Comms input (Terminal 26) to common (Terminal 25).

Click the Online toolbar button. Once online, click the Parameters toolbar button. All of the parameters are displayed and can be edited by double clicking. The following sections explain in detail the function of each parameter.

The MicroManager's parameters are grouped into numerous functional blocks. Please refer to drawing D13596 on page 36 for an overall view of all the blocks. Each parameter has a descriptive name and a tag (or number) identifier. The following sections contain each software block diagram and descriptions of each parameter function. Refer to Figure 3 below for key conventions that are used in the block diagrams. Each parameter is one of two types: Read-Only (RO) or Read-Write (RW). Remember that parameter changes must be saved by clicking on the MM Save toolbar button or by setting the Save parameter (parameter 1) to 1.

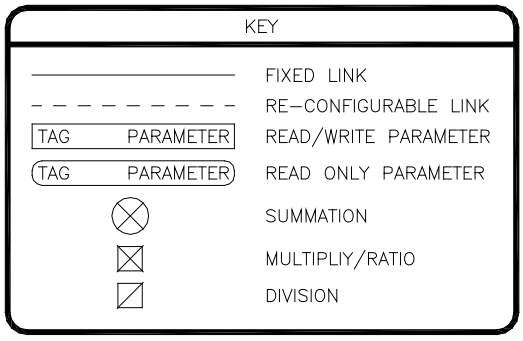


Figure 3: Block Diagram Key

5.1 Digital Inputs

The MM3010-MBS has four digital inputs. The inputs can be set for Sinking or Sourcing logic via Terminal 8.

If Terminal 8 is connected to Terminal 9, sinking mode is selected. In Sinking mode, the digital input terminals are at a nominal voltage of 24VDC. An external device (such as a contact) must sink (pull down) the input to common (Terminal 7) to activate the input.

If Terminal 8 is connected to Terminal 7, sourcing mode is selected. In Sourcing mode, the digital input terminals are at a nominal voltage of 0VDC. An external device (such as a contact) must source current (drive the input high) to activate the input.

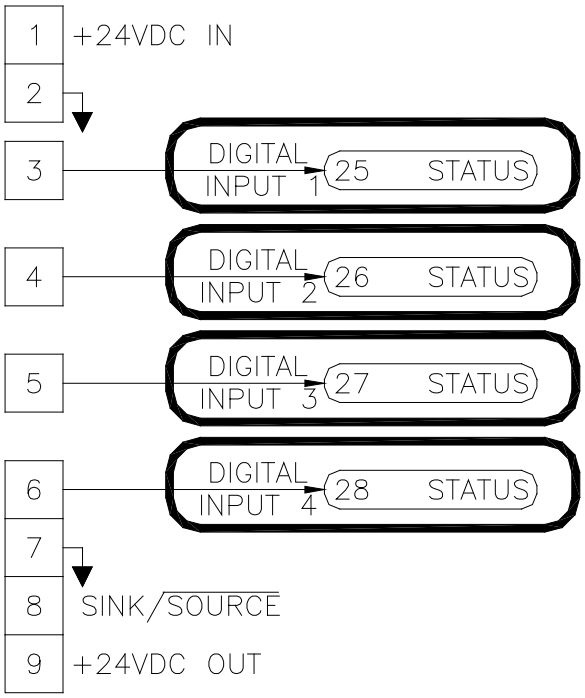


Figure 4: Digital Inputs

Status (25-28, Read Only)
The status parameter contains the state of the digital input: off (0) or on (1).

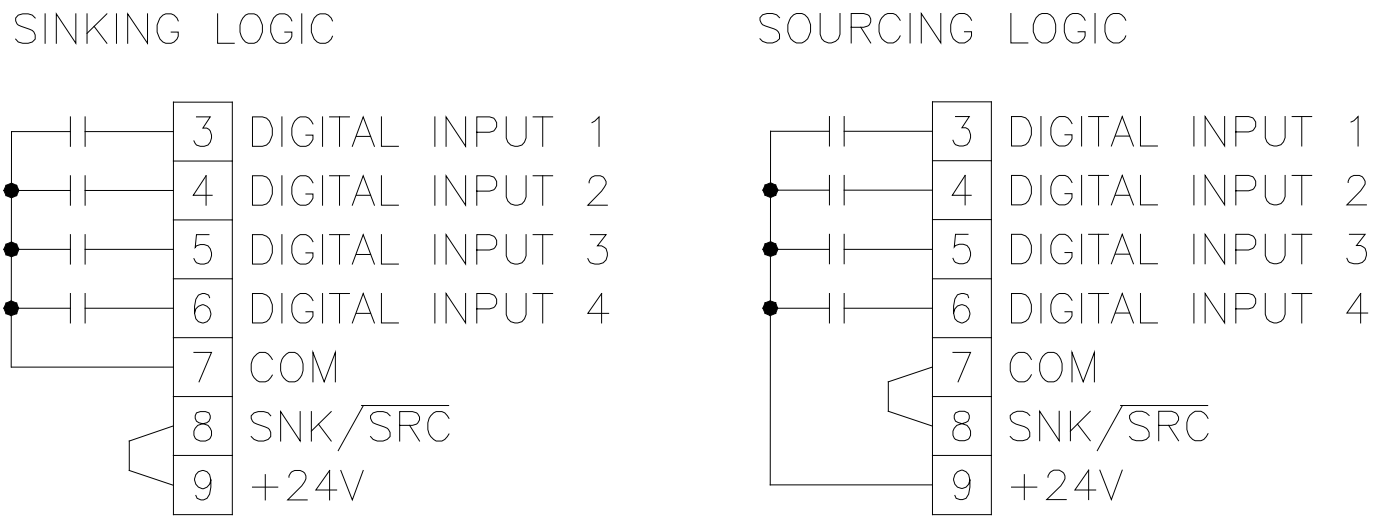


Figure 5: Sinking/Sourcing Examples

5.2 Voltage Inputs

The MM3010-MBS has four bipolar voltage inputs. The 13 bit analog-to-digital conversion value is stored in the Status parameter. Each of the inputs has a filtering (averaging) adjustment.

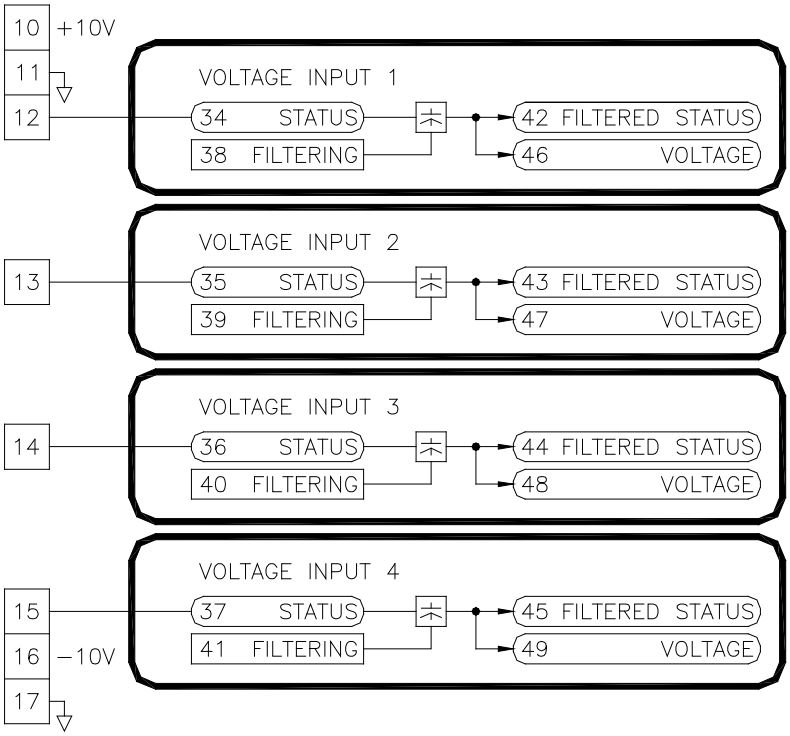


Figure 6: Voltage Inputs

Status (34-37, Read Only)

The Status parameter contains the 13 bit analog-to-digital conversion (ADC) value. Typical readings are listed below.

Input Voltage	Status
+10.0	4095
+5.0	2047
0	0
-5.0	-2048
-10.0	-4096

Table 1: Voltage Input Status Readings

Filtering (38-41, Read/Write, default: 0)

An averaging filter can be applied to the incoming signal to reduce the effects of noise. Increasing the value increases the filtering. A value of zero turns off the filtering. The max value of 15 is heavily filtered.

Filtered Status (42-45, Read Only)

The Filtered Status parameter contains the filtered (averaged) 13 bit analog-to-digital conversion (ADC) value.

Voltage (46-49, Read Only)

The Voltage parameter contains the voltage level (after filtering) on the terminal.

5.3 Current Inputs

The MM3010-MBS has two current inputs. The 10 bit analog-to-digital converter is oversampled to approach a 12 bit value. The converted value is stored in the Status parameter. Each of the inputs has a filtering (averaging) adjustment.

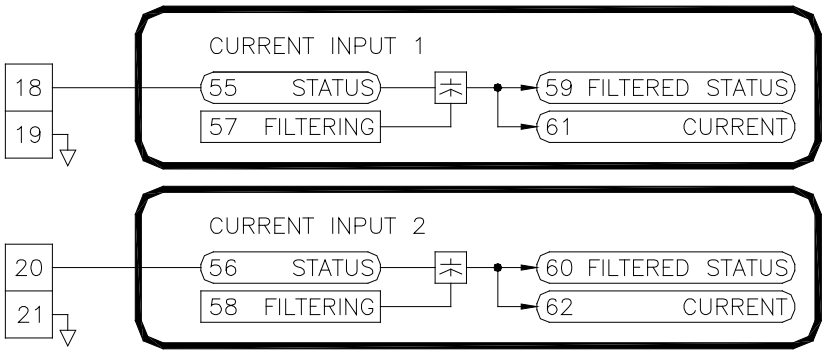


Figure 7: Current Inputs

Status (55-56, Read Only)
The Status parameter contains the near 12 bit analog-to-digital conversion (ADC) value. Typical readings are listed below.

Input Current (mA)	Status
20.0	4092
16.0	3274
12.0	2455
8.0	1637
4.0	818
0.0	0

Table 2: Current Input Status Readings

Filtering (57-58, Read/Write, default: 0)
An averaging filter can be applied to the incoming signal to reduce the effects of noise. Increasing the value increases the filtering. A value of zero turns off the filtering. The max value of 15 is heavily filtered.

Filtered Status (59-60, Read Only)
The Filtered Status parameter contains the filtered (averaged) analog-to-digital conversion (ADC) value.

Current (61-62, Read Only)
The Voltage parameter contains the voltage level (after filtering) on the terminal.

5.4 Frequency/Counter Inputs

The MM3010-MBS has two frequency inputs. Additionally, each input can simultaneously function as a pulse counter.

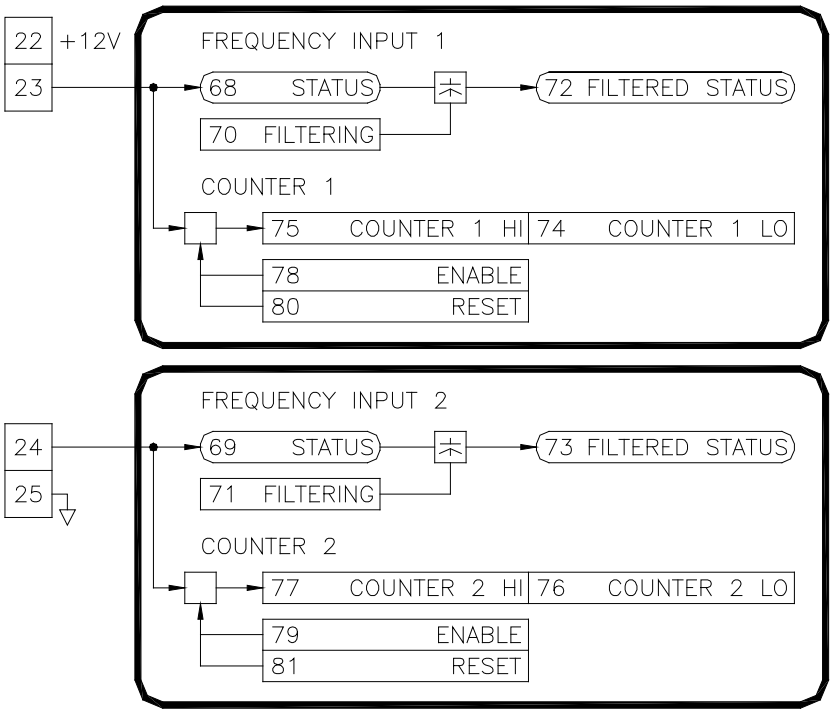


Figure 8: Frequency Inputs

Status (68-69, Read Only)
The level of the input signal in Hertz.

Filtering (70-71, Read/Write, default: 0)
An averaging filter can be applied to the incoming signal to reduce the effects of noise. Increasing the value increases the filtering. A value of zero turns off the filtering. The max value of 15 is heavily filtered.

Filtered Status (72-73, Read Only)
The Filtered Status parameter contains the filtered (averaged) frequency value.

Counter (74-77, Read/Write)
The value of the pulse counter. When **Count Enable** is 1, every falling edge on the input signal causes the value to increase by 1. In order to accommodate for high resolution encoders, each counter is implemented as a 32 bit integer and thus has a high 16 bit word and a low 16 bit word. The counters have an upper limit of 4,294,967,295.

Enable (78-79, Read/Write, default: 0)
When this parameter is 1, each falling edge on the input terminal causes the associated counter to be incremented by one.

Reset (80-81, Read/Write, default: 0)
When this parameter is 1, the Counter is reset to zero.

5.5 Analog Outputs

The MM3010-MBS has four analog outputs. Two of the analog outputs (1 & 2) are available as voltage and/or current. The desired output type is chosen by connecting to the appropriate output terminal. The remaining two analog outputs are available as voltage only.

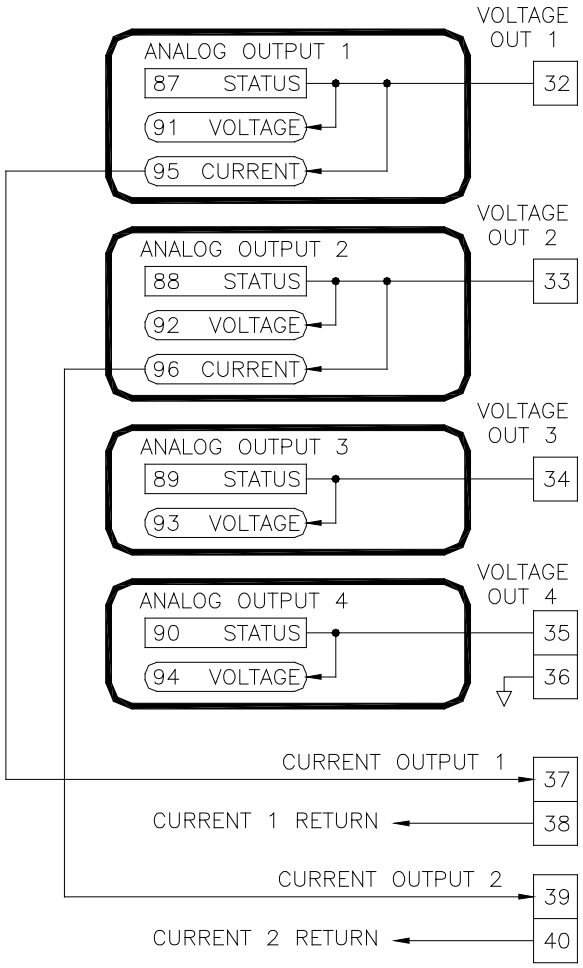


Figure 9: Analog Outputs

Status (87-90, Read/Write)
The raw 12 bit digital to analog value. Typical readings are listed below.

Status	Voltage (V)	Current (mA)
2047	+10.0	20
1023	+5.0	15
0	0.0	10
-1024	-5.0	5
-2048	-10.0	0

Table 3: Analog Output Status Readings

Voltage (91-94, Read Only)
The commanded voltage output level.

Current (95-96, Read Only)
The commanded current output level.

5.6 Relay Outputs

The MM3010-MBS has four Form C relay outputs.

Status (102-105, Read/Write)
The command state of the relay output. A value of 1 energizes the relay and a value of 0 de-energizes the relay. The relay output contacts below are shown in the de-energized state.

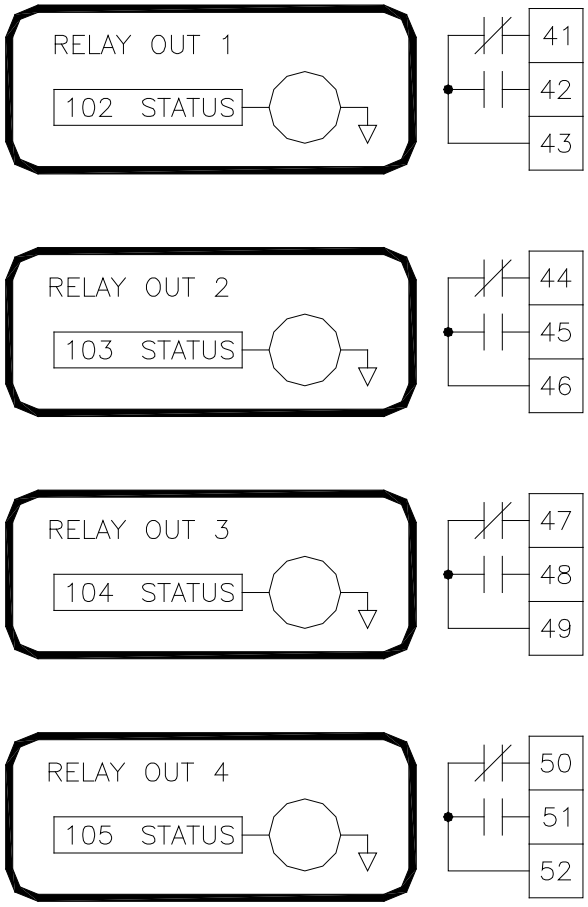


Figure 10: Relay Outputs

5.7 Communications

Model MM3010-MBS is equipped with two Modbus RTU RS485 slave ports. Each port can operate in either 2 wire or 4 wire mode. The primary port is provided on terminals 27-31. The secondary port is provided as modular 6 pin connector on the face of the unit. Refer to D13633 on page 35 for connection information.

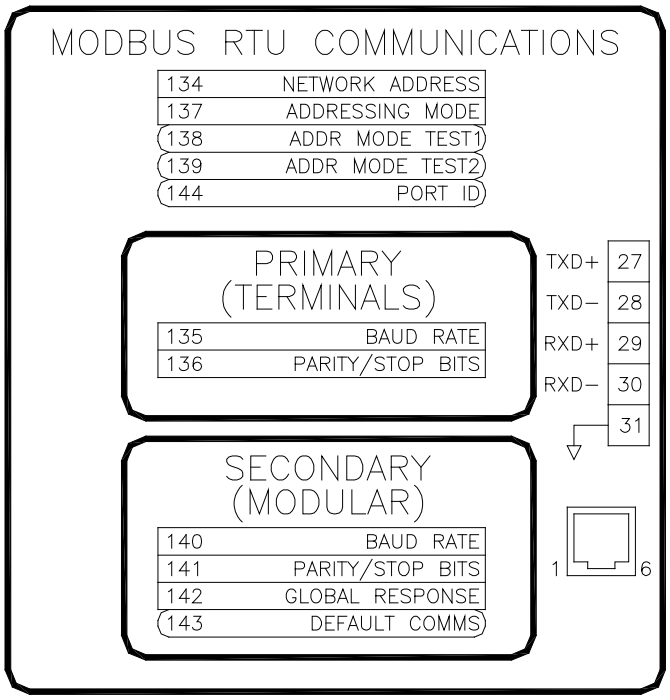


Figure 11: Modbus RTU Communications

Network Address (134, Read/Write, default: 1)
The address of the MM3010-MBS on the Modbus network. Each device on the bus must have a unique network address. This parameter applies to both the primary and secondary ports.

Addressing Mode (137, Read/Write, default: 1)
In the Modbus specification, registers are addressed using an offset. For example, to read register 1, an address of 0 must be used. Much of the available Modbus master communications equipment (PLC's and touchscreens) take this offset into account. Therefore, to read register 1, an address of 1 is used when programming. The master device will decrement the address before requesting it from the slave.

However, not all master devices take this offset into account. The **Addressing Mode** parameter can be used to implement either scheme and "match up" the addresses so that the actual address is used to address that register (making programming much easier).

In order to determine which mode to use with a particular master, have the master read the **Address Mode Test 2** parameter. If the returned value is 0xAAAA in hex, everything is correct. If the returned value is 0x5555 (the value of **Address Mode Test 1**), then the **Addressing Mode** parameter needs to be changed. This parameter applies to both the primary and secondary ports.

Addressing Mode Test 1 (138, Read Only)
Test parameter that has a fixed value of 21845 (5555 in hex).

Addressing Mode Test 2 (139, Read Only)
Test parameter that has a fixed value of 43690 (AAAA in hex).

Port ID (144, Read Only)
This parameter is unique in that its value is dependent upon which communication channel is used to read the register. When read via the primary port, this register will have a value of 0. When read via the secondary port, this register will have a value of 1.

Primary Port Baud Rate (135, Read/Write, default: 4)
Sets the transmit and receive rate of data over the primary Modbus port.

Setting	Baud
0	2400
1	4800
2	9600
3	19200
4	**38400**

Table 4: Baud Rate Settings

Primary Port Parity/Stop Bits (136, Read/Write, default: 1)
Sets the parity and number of stop bits for the primary Modbus port.

Setting	Parity, Stop Bits
0	None,1
1	**None,2**
2	Even,1
3	Odd,1

Table 5: Parity Stop Bits Settings

Secondary Port Baud Rate (140, Read/Write, default: 4)
Sets the transmit and receive rate of data over the secondary Modbus port. See Table 4 for settings.

Secondary Port Parity/Stop Bits (141, Read/Write, default: 1)
Sets the parity and number of stop bits for the secondary Modbus port. See Table 5 for settings.

Secondary Port Global Response (142, Read/Write, default: 1)
When set to 1, this allows the secondary port to respond to all Modbus commands regardless of the network address. When set to 0, the secondary port will only respond to commands that match the **Network Address** parameter.

Secondary Port Default Comms (143, Read Only)
If the secondary port communication parameters are unknown, they can be forced into the default state by connecting terminal 26 to terminal 25.

5.8 System Parameters

Save (1, Read/Write, default: 0)
Parameter changes take affect immediately. However, in order to make the changes permanent, the save command must be used. Setting this parameter to 1 causes all of the parameters to be written to the internal EEPROM. The Save Status parameter can be used to determine if the parameters were saved successfully.

Save Status (2, Read Only)
Result of the Save command.

Save Status	Description
0	Saved Successfully
1	Saving in progress
2	Error

Table 6: Save Status Readings

Re-Initialize (3, Read/Write, default: 0)
Used to re-initialize the MM3010-MBS to its default state.

Initialized Status (4, Read/Write, default: 0)
This parameter reflects the most recent value of the Initialize parameter.

Customization Code (5-6, Read Only)
For engineering use only.

Main Processor ID (7, Read Only)
Identification code for the main internal processor. For engineering use only.

Main Processor Revision (8, Read Only)
Hardware revision of the main internal processor. For engineering use only.

Main Processor Firmware Version (9, Read Only)
Version code of the main processor's internal firmware.

Main Processor Boot Firmware Version (10, Read Only)
Version code of the main processor's internal boot firmware.

Main Processor System Status (11, Read Only)
Status register that provides the source of the most recent reset on the main processor. For engineering use only.

System Status	Description
1	Brown Out Reset
2	Power On Reset
4	Power Down Detection
8	Watchdog Timeout
16	Reset Instruction

Table 7: System Status Readings

Aux Processor ID (12, Read Only)
Identification code for the aux internal processor. For engineering use only.

Aux Processor Revision (13, Read Only)
Hardware revision of the aux internal processor. For engineering use only.

Aux Processor Firmware Version (14, Read Only)
Version code of the aux processor's internal firmware.

Aux Processor Boot Firmware Version (15, Read Only)
Version code of the aux processor's internal boot firmware.

Aux Processor System Status (16, Read Only)
Status register that provides the source of the most recent reset on the aux processor. For engineering use only.

PCB Revision (17, Read Only)
For engineering use only.

Total Parameters (18, Read Only)
The total number of parameters.

Changes Need Saving (19, Read Only)
Status bit that indicates parameters have been changed but not saved.

5.9 Auxiliary Parameters

The MicroManager provides 10 auxiliary parameters for general use.

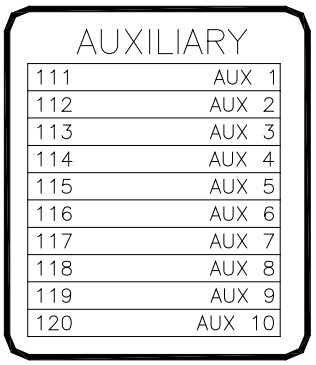


Figure 12: Auxiliary Parameters

5.10 Parameter Table

The following two tables lists all the MicroManager MBS parameters and their properties. RO indicates ***R**ead-**O**nly* parameters.

Table 8: Parameter List

Tag	Parameter Name	Min	Max	RO	Preset	User
0	Trash	0	65535		0	
1	Save	0:False	1:True		0:False	
2	Save Status	0: Save Successful 1: Saving in Progress 2: Save Error		RO	0:Save Successful	
3	Initialize				0	
4	Model	4:MBS		RO	4:MBS	
5	Customization Code (LSW)	0	65535	RO	0	
6	Customization Code (MSW)	0	65535	RO	0	
7	Main Processor ID	0	2047	RO	0	
8	Main Processor Hardware Revision	0	31	RO	0	
9	Main Processor Firmware Version	0	9999	RO	-	
10	Main Processor Boot Version	0	9999	RO	-	
11	Main Processor System Status	0	65535	RO	0	
12	Aux Processor ID	0	2047	RO	0	
13	Aux Processor Hardware Revision	0	31	RO	0	
14	Aux Processor Firmware Version	0	9999	RO	-	
15	Aux Processor Boot Version	0	9999	RO	-	
16	Aux Processor System Status	0	65535	RO	0	
17	PCB Revision	0	1023	RO	0	
18	Total Parameters	0	65535	RO	-	
19	Changes Need Saving	0:False	1:True	RO	0:False	
20	Reserved	0	65535	RO	0	
21	Reserved	0	65535	RO	0	
22	Reserved	0	65535	RO	0	
23	Reserved	0	65535	RO	0	
24	Reserved	0	65535	RO	0	
25	Digital Input 1 Status	0:Off	1:On	RO	0:Off	
26	Digital Input 2 Status	0:Off	1:On	RO	0:Off	
27	Digital Input 3 Status	0:Off	1:On	RO	0:Off	
28	Digital Input 4 Status	0:Off	1:On	RO	0:Off	
29	Reserved	0	65535	RO	0	
30	Reserved	0	65535	RO	0	
31	Reserved	0	65535	RO	0	
32	Reserved	0	65535	RO	0	
33	Reserved	0	65535	RO	0	
34	Voltage Input 1 Status	-4096	4095	RO	0	
35	Voltage Input 2 Status	-4096	4095	RO	0	
36	Voltage Input 3 Status	-4096	4095	RO	0	
37	Voltage Input 4 Status	-4096	4095	RO	0	
38	Voltage Input 1 Filtering	0	15		0	
39	Voltage Input 2 Filtering	0	15		0	
40	Voltage Input 3 Filtering	0	15		0	
41	Voltage Input 4 Filtering	0	15		0	
42	Voltage Input 1 Filtered Status	-4096	4095	RO	0	
43	Voltage Input 2 Filtered Status	-4096	4095	RO	0	
44	Voltage Input 3 Filtered Status	-4096	4095	RO	0	
45	Voltage Input 4 Filtered Status	-4096	4095	RO	0	
46	Voltage Input 1 Voltage (V)	-10.00V	10.00V	RO	0.00V	
47	Voltage Input 2 Voltage (V)	-10.00V	10.00V	RO	0.00V	
48	Voltage Input 3 Voltage (V)	-10.00V	10.00V	RO	0.00V	

Tag	Parameter Name	Min	Max	RO	Preset	User
49	Voltage Input 4 Voltage (V)	-10.00V	10.00V	RO	0.00V	
50	Reserved	0	65535	RO	0	
51	Reserved	0	65535	RO	0	
52	Reserved	0	65535	RO	0	
53	Reserved	0	65535	RO	0	
54	Reserved	0	65535	RO	0	
55	Current Input 1 Status	0	4092	RO	0	
56	Current Input 2 Status	0	4092	RO	0	
57	Current Input 1 Filtering	0	15		0	
58	Current Input 2 Filtering	0	15		0	
59	Current Input 1 Filtered Status	0	4092	RO	0	
60	Current Input 2 Filtered Status	0	4092	RO	0	
61	Current Input 1 Current (mA)	0.0mA	20.0mA	RO	0.0mA	
62	Current Input 2 Current (mA)	0.0mA	20.0mA	RO	0.0mA	
63	Reserved	0	65535	RO	0	
64	Reserved	0	65535	RO	0	
65	Reserved	0	65535	RO	0	
66	Reserved	0	65535	RO	0	
67	Reserved	0	65535	RO	0	
68	Frequency Input 1 Status	0	50000Hz	RO	0Hz	
69	Frequency Input 2 Status	0	50000Hz	RO	0Hz	
70	Frequency Input 1 Filtering	0	15		0	
71	Frequency Input 2 Filtering	0	15		0	
72	Frequency Input 1 Filtered Status	0	50000Hz	RO	0Hz	
73	Frequency Input 2 Filtered Status	0	50000Hz	RO	0Hz	
74	Counter 1 Low Word	0	65535		0	
75	Counter 1 High Word	0	65535		0	
76	Counter 2 Low Word	0	65535		0	
77	Counter 2 High Word	0	65535		0	
78	Counter 1 Enable	0:False	1:True		0:False	
79	Counter 2 Enable	0:False	1:True		0:False	
80	Counter 1 Reset	0:False	1:True		0:False	
81	Counter 2 Reset	0:False	1:True		0:False	
82	Reserved	0	65535	RO	0	
83	Reserved	0	65535	RO	0	
84	Reserved	0	65535	RO	0	
85	Reserved	0	65535	RO	0	
86	Reserved	0	65535	RO	0	
87	Analog Output 1 Status	-4096	4095	RO	0	
88	Analog Output 2 Status	-4096	4095	RO	0	
89	Analog Output 3 Status	-4096	4095	RO	0	
90	Analog Output 4 Status	-4096	4095	RO	0	
91	Analog Output 1 Voltage	-10.00V	10.00V	RO	0.00V	
92	Analog Output 2 Voltage	-10.00V	10.00V	RO	0.00V	
93	Analog Output 3 Voltage	-10.00V	10.00V	RO	0.00V	
94	Analog Output 4 Voltage	-10.00V	10.00V	RO	0.00V	
95	Analog Output 1 Current	0.0mA	20.0mA	RO	10.0mA	
96	Analog Output 2 Current	0.0mA	20.0mA	RO	10.0mA	
97	Reserved	0	65535	RO	0	
98	Reserved	0	65535	RO	0	
99	Reserved	0	65535	RO	0	
100	Reserved	0	65535	RO	0	
101	Reserved	0	65535	RO	0	
102	Relay Output 1 Status	0:Off	1:On		0:Off	
103	Relay Output 2 Status	0:Off	1:On		0:Off	
104	Relay Output 3 Status	0:Off	1:On		0:Off	
105	Relay Output 4 Status	0:Off	1:On		0:Off	

Tag	Parameter Name	Min	Max	RO	Preset	User
106	Reserved	0	65535	RO	0	
107	Reserved	0	65535	RO	0	
108	Reserved	0	65535	RO	0	
109	Reserved	0	65535	RO	0	
110	Reserved	0	65535	RO	0	
111	Aux 1	0	65535		0	
112	Aux 2	0	65535		0	
113	Aux 3	0	65535		0	
114	Aux 4	0	65535		0	
115	Aux 5	0	65535		0	
116	Aux 6	0	65535		0	
117	Aux 7	0	65535		0	
118	Aux 8	0	65535		0	
119	Aux 9	0	65535		0	
120	Aux 10	0	65535		0	
121	Reserved	0	65535	RO	0	
122	Reserved	0	65535	RO	0	
123	Reserved	0	65535	RO	0	
124	Reserved	0	65535	RO	0	
125	Reserved	0	65535	RO	0	
126	Reserved	0	65535	RO	0	
127	Reserved	0	65535	RO	0	
128	Reserved	0	65535	RO	0	
129	Reserved	0	65535	RO	0	
130	Reserved	0	65535	RO	0	
131	Reserved	0	65535	RO	0	
132	Reserved	0	65535	RO	0	
133	Reserved	0	65535	RO	0	
134	Network Address	1	247		1	
135	Primary Port Baud Rate	0: 2400 1: 4800 2: 9600 3: 19200 4: 38400			4: 38400	
136	Primary Port Parity-Stop Bits	0: No Parity, 1 Stop Bit 1: No Parity, 2 Stop Bits 2: Even Parity, 1 Stop Bit 3: Odd Parity, 1 Stop Bit			1: No Parity, 2 Stop Bits	
137	Addressing Mode	0	1		1	
138	Addressing Mode Test 1	21845	21845	RO	21845	
139	Addressing Mode Test 2	43690	43690	RO	43690	
140	Secondary Port Baud Rate	0: 2400 1: 4800 2: 9600 3: 19200 4: 38400			4: 38400	
141	Secondary Port Parity-Stop Bits	0: No Parity, 1 Stop Bit 1: No Parity, 2 Stop Bits 2: Even Parity, 1 Stop Bit 3: Odd Parity, 1 Stop Bit			1: No Parity, 2 Stop Bits	
142	Secondary Port Global Response	0:Off	1:On		1:On	
143	Secondary Port Default Comms	0:Off	1:On		1:Off	
144	Port ID	0:Primary	1:Secondary			

6 Modbus® Overview

6.1 Modbus® Protocol

The MicroManager supports a subset of the Modbus® RTU communications protocol. This section describes the MicroManager's implementation of the protocol. For a complete detailed specification of the entire Modbus® protocol, please refer to http://www.modbus.org.

In the MicroManager, functions 1,2,3,4,5,6,8,15, & 16 are supported. The message format or frame varies depending upon which function code is used. Each frame is started by the slave address and ends with a CRC-16 error checking code. If the slave addresses do not match or the CRC-16 code is invalid, the slave ignores the message and no response is returned. The MicroManager acts as a slave (server) to a single master (client). Bus contentions are avoided since the Modbus® master initiates all communications. Slave devices only place data on the bus in response to a master's request. Each slave device on the bus must have a unique network address.

Frames consist of 8 bit data bytes. Parity can set for None, Odd, or Even. Frames are separated on the bus by a silent period in which no data transmissions occur. This silent period thus signals devices on the bus when a frame has ended and can now begin to examine the frame data. Bytes within a frame must therefore be sent in a continuous stream to avoid silent periods.

The Modbus® protocol uses two general types of data: bits and registers. Registers are composed of 16 bits. Some slave devices further divide each of these data types depending upon its method of access (read-write or read-only). The MicroManager makes no distinction between read-write and read-only with respect to the command. For example, any register can be read by using Function Code 3 or 4, and any bit can be read using Function Codes 1 or 2. Attempts to write a value to a read-only parameter are ignored.

Since all of the MicroManager's parameters are implemented internally as 16 bit registers, each parameter can be accessed by using a bit or a register command. Thus, a register can be read or written to by a bit command. In these cases, any non-zero value is interpreted as True (1) and zero is interpreted as False (0).

In the following, hexadecimal number are represented with an 'h' suffix and binary numbers with a 'b' suffix. Decimal data is shown with no suffix.

Code	Function	Data Type	Access	Data Type Code
1 (01h)	Read Bits	bit	(read-write)	0x
2 (02h)	Read Bits	bit	(read-only)	1x
3 (03h)	Read Multiple Registers	16 bit register	(read-write)	4x
4 (04h)	Read Multiple Registers	16 bit register	(read-only)	3x
5 (05h)	Write Single Bit	bit	(read-write)	0x
6 (06h)	Write Single Register	16 bit register	(read-write)	4x
8 (08h)	Diagnostics (Loopback)	-	-	-
15 (0Fh)	Write Multiple Bits	bit	(read-write)	0x
16 (10h)	Write Multiple Registers	16 bit register	(read-write)	4x

Table 9: Supported Modbus® Functions

The table below lists the maximum frame register limits for the Modbus functions that can read or write multiple data values. An exception 3 error response is returned if a quantity exceeding that in the table below is used in a command.

Code	Function	Main Port	Aux Port
1 (01h)	Read Bits	2000 bits	512 bits
2 (02h)	Read Bits	2000 bits	512 bits
3 (03h)	Read Multiple Registers	125 words	32 words
4 (04h)	Read Multiple Registers	125 words	32 words
15 (0Fh)	Write Multiple Bits	1968 bits	32 bits
16 (10h)	Write Multiple Registers	123 words	32 words

Table 10: Maximum Supported Quantities in Modbus® Functions

Function Code 1 (01h) Read Bits
In this example, Function Code 1 is used to read the status of the 4 digital inputs (i.e. parameters 25-28). Digital Inputs 1, 2, & 4 are on.

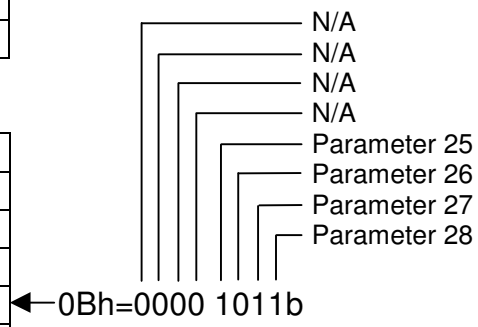
Master Command

Description		Data
Slave Address		01h
Function Code		01h
Starting Address	Upper	00h
	Lower	18h
Quantity	Upper	00h
	Lower	04h
CRC-16	Lower	BDh
	Upper	CEh

} 25-1=0018h*

Normal Slave Response

Description		Data
Slave Address		01h
Function Code		01h
Byte Count		01h
Data		0Bh
CRC-16	Lower	10h
	Upper	4Fh



Error Slave Response

Description		Data
Slave Address		01h
Function Code		81h
Error Code		02h
CRC-16	Lower	C1h
	Upper	91h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0019h would be used.

Function Code 2 (02h) Read Bits

In this example, Function Code 2 is used to read the status of the 4 digital inputs (i.e. parameters 53-56). Digital Inputs 2 & 3 are on.

Master Command

Description		Data
Slave Address		01h
Function Code		02h
Starting Address	Upper	00h
	Lower	18h
Quantity	Upper	00h
	Lower	04h
CRC-16	Lower	F9h
	Upper	CEh

} 25-1=0018h*

Normal Slave Response

Description		Data
Slave Address		01h
Function Code		02h
Byte Count		01h
Data		06h
CRC-16	Lower	21h
	Upper	8Ah

◄—06h=0000 0110b

N/A
N/A
N/A
N/A
Parameter 25
Parameter 26
Parameter 27
Parameter 28

Error Slave Response

Description		Data
Slave Address		01h
Function Code		82h
Error Code		03h
CRC-16	Lower	00h
	Upper	A1h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0019h would be used.

Function Code 3 (03h) Read Multiple Registers
In this example, Function Code 3 is used to read the filtered status of Voltage Inputs 1 & 2 (i.e. parameters 42-43).

Master Command

Description		**Data**	
Slave Address		01h	
Function Code		03h	
Starting Address	Upper	00h	} 42-1=0029h*
	Lower	29h	
Quantity	Upper	00h	
	Lower	02h	
CRC-16	Lower	15h	
	Upper	C3h	

Normal Slave Response

Description		**Data**	
Slave Address		01h	
Function Code		03h	
Byte Count		04h	
Register Data	Upper	00h	} 00BCh=188
	Lower	BCh	
Register Data	Upper	05h	} 0563h=1379
	Lower	63h	
CRC-16	Lower	78h	
	Upper	AEh	

Error Slave Response

Description		**Data**
Slave Address		01h
Function Code		83h
Error Code		02h
CRC-16	Lower	C0h
	Upper	F1h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 002Ah would be used.

Function Code 4 (04h) Read Multiple Registers

In this example, Function Code 4 is used to read the current in milliamps of current inputs 1 and 2. (i.e. parameters 61 & 62). When read, the values were 15.5mA and 10.7mA%.

Master Command

Description		Data	
Slave Address		01h	
Function Code		04h	
Starting Address	Upper	00h	} 61-1=003Ch*
	Lower	3Ch	
Quantity	Upper	00h	
	Lower	02h	
CRC-16	Lower	B1h	
	Upper	C7h	

Normal Slave Response

Description		Data	
Slave Address		01h	
Function Code		04h	
Byte Count		04h	
Register Data	Upper	00h	} 006Bh=107=10.7mA
	Lower	6Bh	
Register Data	Upper	00h	} 009Bh=155=15.5mA
	Lower	9Bh	
CRC-16	Lower	CBh	
	Upper	F3h	

Error Slave Response

Description		Data
Slave Address		01h
Function Code		84h
Error Code		03h
CRC-16	Lower	03h
	Upper	01h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 003Dh would be used.

Function Code 5 (05h) Write Single Bit
In this example, Function Code 5 is used to write a value of 1 to Relay Output 1 (i.e. parameter 102).

Master Command

Description		**Data**	
Slave Address		01h	
Function Code		05h	
Address	Upper	00h	102-1=0065h*
	Lower	65h	
Data	Upper	FFh	FF00h is used to turn bit on. 0000h would be used to turn bit off.
	Lower	00h	
CRC-16	Lower	9Ch	
	Upper	25h	

Normal Slave Response

Description		**Data**
Slave Address		01h
Function Code		05h
Address	Upper	00h
	Lower	65h
Register Data	Upper	FFh
	Lower	00h
CRC-16	Lower	9Ch
	Upper	25h

Error Slave Response

Description		**Data**
Slave Address		01h
Function Code		85h
Error Code		02h
CRC-16	Lower	C3h
	Upper	51h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0066h would be used.

Function Code 6 (06h) Write Single Register
In this example, Function Code 6 is used to write a value of 1023 (+5V & 15mA) to Analog Output 1 (i.e. parameter 87).

Master Command

Description		Data	
Slave Address		01h	
Function Code		06h	
Address	Upper	00h	87-1=0056h*
	Lower	56h	
Data	Upper	03h	1023=03FFh
	Lower	FFh	
CRC-16	Lower	29h	
	Upper	6Ah	

Normal Slave Response

Description		Data
Slave Address		01h
Function Code		06h
Address	Upper	00h
	Lower	56h
Register Data	Upper	03h
	Lower	FFh
CRC-16	Lower	29h
	Upper	6Ah

Error Slave Response

Description		Data
Slave Address		01h
Function Code		86h
Error Code		02h
CRC-16	Lower	C3h
	Upper	A1h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0057h would be used.

Function Code 8 (08h) Diagnostics, Echo Data
In this example, Function Code 8 (Diagnostics) with Sub Code 0 (Echo Data) is used to test communications with a slave device. The slave should echo back the received data.

Master Command

Description		**Data**
Slave Address		01h
Function Code		08h
Sub Code	Upper	00h
	Lower	00h
Data	Upper	AAh
	Lower	55h
CRC-16	Lower	5Eh
	Upper	94h

Normal Slave Response

Description		**Data**
Slave Address		01h
Function Code		08h
Sub Code	Upper	00h
	Lower	00h
Data	Upper	AAh
	Lower	55h
CRC-16	Lower	5Eh
	Upper	94h

Error Slave Response

Description		**Data**
Slave Address		01h
Function Code		88h
Error Code		01h
CRC-16	Lower	87h
	Upper	C0h

Function Code 15 (0Fh) Write Multiple Bits

In this example, Function Code 15 is used to write a value of 0 to Relay Output 1 and a value of 1 to Relay Output 2 (i.e. parameters 102 & 103).

Master Command

Description		Data
Slave Address		01h
Function Code		0Fh
Start Address	Upper	00h
	Lower	65h
Num Bits	Upper	00h
	Lower	02h
Byte Count		01h
Data		02h
CRC-16	Lower	13h
	Upper	5Eh

102-1=0065h*

Normal Slave Response

Description		Data
Slave Address		01h
Function Code		0Fh
Start Address	Upper	00h
	Lower	65h
Num Bits	Upper	00h
	Lower	02h
CRC-16	Lower	C4h
	Upper	15h

Error Slave Response

Description		Data
Slave Address		01h
Function Code		8Fh
Error Code		02h
CRC-16	Lower	C5h
	Upper	F1h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 0066h would be used.

Function Code 16 (10h) Write Multiple Registers
In this example, Function Code 16 is used to preset Counter 1 to the value of 131,052. (i.e. parameters 74 & 75).

Master Command

Description		Data
Slave Address		01h
Function Code		10h
Start Address	Upper	00h
	Lower	49h
Register Count	Upper	00h
	Lower	02h
Byte Count		04h
Register Data	Upper	00h
	Lower	01h
Register Data	Upper	FFh
	Lower	ECh
CRC-16	Lower	26h
	Upper	48h

} 74-1=0049h*

} 131052=0001FFECh

Normal Slave Response

Description		Data
Slave Address		01h
Function Code		10h
Start Address	Upper	00h
	Lower	49h
Register Count	Upper	00h
	Lower	02h
CRC-16	Lower	90h
	Upper	1Eh

Error Slave Response

Description		Data
Slave Address		01h
Function Code		90h
Error Code		02h
CRC-16	Lower	CDh
	Upper	C1h

*This assumes the MicroManager Addressing Mode (parameter 137) is set to 1 (default). If Addressing Mode is set to 0, then the Address does not need to be decremented by one. In this mode a value of 004Ah would be used.

6.3 CRC-16 Calculations

CRC stands for Cyclical Redundancy Check and is a 16 bit value appended to all Modbus® frames. When a device (either master or slave) places data on the bus, the CRC value is appended to the message. The receiving device also calculates a CRC value as it receives the message. The receiver compares its calculated value to the one received. A transmission error has occurred if the values do not match.

Please note that when the CRC value is appended to a message, the low byte is appended first followed by the upper byte. This is different from all other Modbus® data fields where the upper byte is sent first followed by the lower byte.

Below is some example C code to generate a CRC-16 value. The method used below provides for fast generation of the CRC value by using lookup tables that contain pre-calculated CRC values. Please refer to the Modbus® specification (available at http://www.modbus.org) for more details.

```
// The function returns the CRC value. Note that this function internally swaps the high and low CRC bytes.
// Thus, the resulting value can be appended directly to the Modbus® message. Msg is a pointer to the
// message that CRC is to be calculated from. DataLen is the quantity of bytes in the message
unsigned int CRC16 (unsigned char *Msg, unsigned char DataLen)
        {
        unsigned char CRCHi = 0xFF;                 // Initialize high byte of CRC
        unsigned char CRCLo = 0xFF;                 // Initialize low byte of CRC
        unsigned char Index;                        // index into CRC lookup table
        while (DataLen--)                           // pass through message buffer
                {
                Index = CRCLo ^ *Msg++;             //calculate the CRC
                CRCLo = CRCHi ^ CRCHi[Index} ;
                CRCHi = CRCLo[Index] ;
                }
        return (CRCHi << 8 | CRCLo) ;
        }
```

High-Order Byte Table

```
// Table of CRC values for high–order byte
static unsigned char CRCHi[] = {
        0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,
        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
        0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,
        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
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        0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,
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        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
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        0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,
        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
        0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,
        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
        0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40,0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,
        0x00,0xC1,0x81,0x40,0x01,0xC0,0x80,0x41,0x01,0xC0,0x80,0x41,0x00,0xC1,0x81,0x40
        } ;
```

Low-Order Byte Table

```
// Table of CRC values for low–order byte
static char CRCLo[] = {
        0x00,0xC0,0xC1,0x01,0xC3,0x03,0x02,0xC2,0xC6,0x06,0x07,0xC7,0x05,0xC5,0xC4,0x04,
        0xCC,0x0C,0x0D,0xCD,0x0F,0xCF,0xCE,0x0E,0x0A,0xCA,0xCB,0x0B,0xC9,0x09,0x08,0xC8,
        0xD8,0x18,0x19,0xD9,0x1B,0xDB,0xDA,0x1A,0x1E,0xDE,0xDF,0x1F,0xDD,0x1D,0x1C,0xDC,
        0x14,0xD4,0xD5,0x15,0xD7,0x17,0x16,0xD6,0xD2,0x12,0x13,0xD3,0x11,0xD1,0xD0,0x10,
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        0x3C,0xFC,0xFD,0x3D,0xFF,0x3F,0x3E,0xFE,0xFA,0x3A,0x3B,0xFB,0x39,0xF9,0xF8,0x38,
        0x28,0xE8,0xE9,0x29,0xEB,0x2B,0x2A,0xEA,0xEE,0x2E,0x2F,0xEF,0x2D,0xED,0xEC,0x2C,
        0xE4,0x24,0x25,0xE5,0x27,0xE7,0xE6,0x26,0x22,0xE2,0xE3,0x23,0xE1,0x21,0x20,0xE0,
        0xA0,0x60,0x61,0xA1,0x63,0xA3,0xA2,0x62,0x66,0xA6,0xA7,0x67,0xA5,0x65,0x64,0xA4,
        0x6C,0xAC,0xAD,0x6D,0xAF,0x6F,0x6E,0xAE,0xAA,0x6A,0x6B,0xAB,0x69,0xA9,0xA8,0x68,
        0x78,0xB8,0xB9,0x79,0xBB,0x7B,0x7A,0xBA,0xBE,0x7E,0x7F,0xBF,0x7D,0xBD,0xBC,0x7C,
        0xB4,0x74,0x75,0xB5,0x77,0xB7,0xB6,0x76,0x72,0xB2,0xB3,0x73,0xB1,0x71,0x70,0xB0,
        0x50,0x90,0x91,0x51,0x93,0x53,0x52,0x92,0x96,0x56,0x57,0x97,0x55,0x95,0x94,0x54,
        0x9C,0x5C,0x5D,0x9D,0x5F,0x9F,0x9E,0x5E,0x5A,0x9A,0x9B,0x5B,0x99,0x59,0x58,0x98,
        0x88,0x48,0x49,0x89,0x4B,0x8B,0x8A,0x4A,0x4E,0x8E,0x8F,0x4F,0x8D,0x4D,0x4C,0x8C,
        0x44,0x84,0x85,0x45,0x87,0x47,0x46,0x86,0x82,0x42,0x43,0x83,0x41,0x81,0x80,0x40
}
```
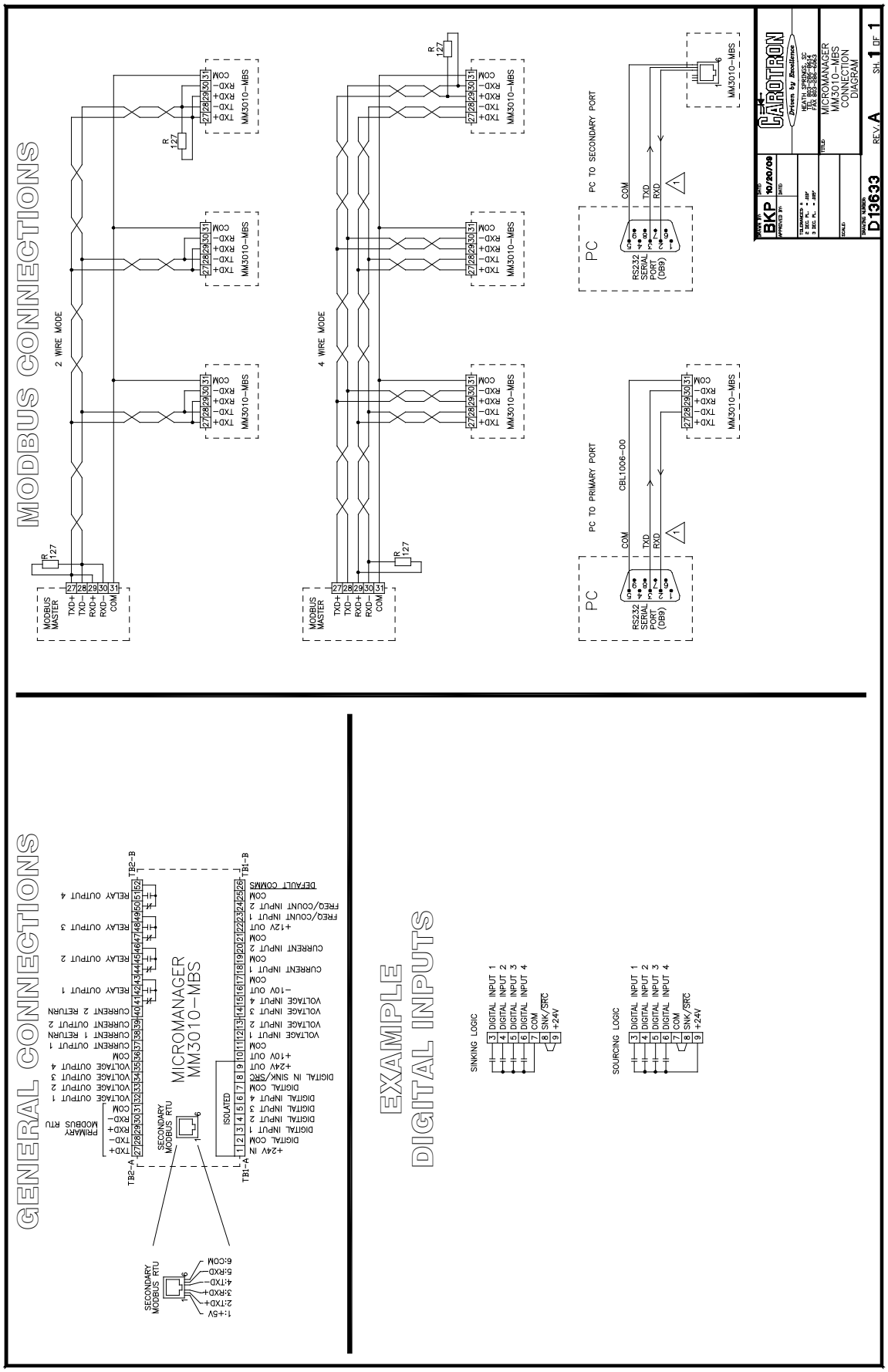
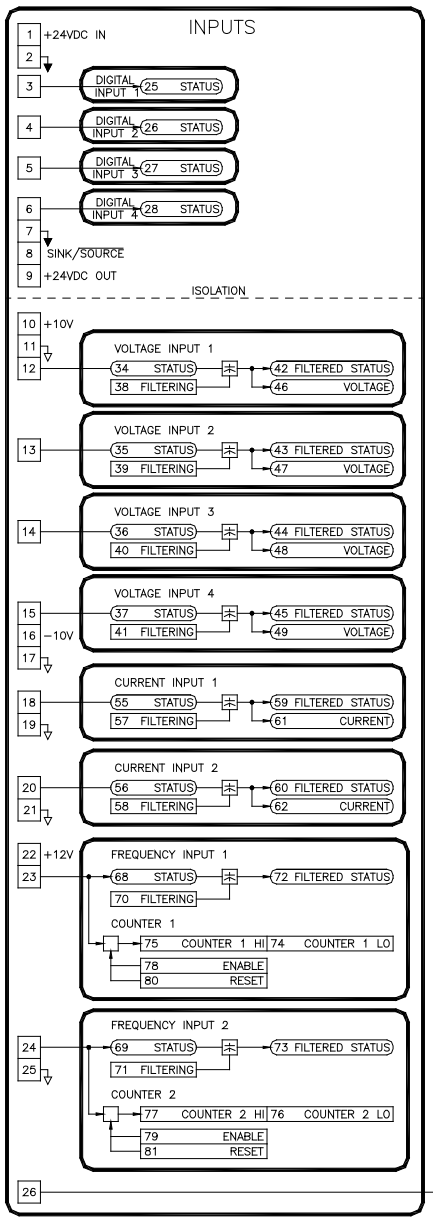
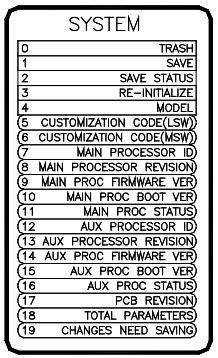

7 Prints

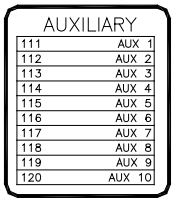

MODBUS CONNECTIONS
2 WIRE MODE
4 WIRE MODE
MODBUS MASTER
TXD+
TXD–
RXD+
RXD–
COM
R 127
MM3010–MBS
PC
PC TO SECONDARY PORT
PC TO PRIMARY PORT
CBL1006–00
RS232 SERIAL PORT (DB9)
TXD
RXD
CAROTRON
MICROMANAGER MM3010–MBS CONNECTION DIAGRAM
BKP
10/20/08
D13633
REV A
SH 1 OF 1

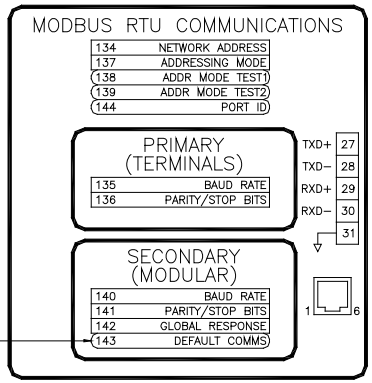
GENERAL CONNECTIONS
MICROMANAGER MM3010–MBS
TB1–A
TB1–B
TB2–A
TB2–B
ISOLATED
SECONDARY MODBUS RTU
PRIMARY MODBUS RTU
+24V IN
DIGITAL COM
DIGITAL INPUT 1
DIGITAL INPUT 2
DIGITAL INPUT 3
DIGITAL INPUT 4
DIGITAL SINK/SRC
+24V OUT
+10V OUT
COM
VOLTAGE INPUT 1
VOLTAGE INPUT 2
VOLTAGE INPUT 3
VOLTAGE INPUT 4
–10V OUT
COM
CURRENT INPUT 1
CURRENT INPUT 2
COM
+12V OUT
FREQ/COUNT INPUT 1
FREQ/COUNT INPUT 2
COM
DEFAULT COMMS
RELAY OUTPUT 1
RELAY OUTPUT 2
RELAY OUTPUT 3
RELAY OUTPUT 4
CURRENT 2 RETURN
CURRENT 1 RETURN
CURRENT OUTPUT 2
CURRENT OUTPUT 1
VOLTAGE OUTPUT 4
VOLTAGE OUTPUT 3
VOLTAGE OUTPUT 2
VOLTAGE OUTPUT 1
COM
TXD+
TXD–
RXD+
RXD–
1:+5V
2:TXD+
3:RXD+
4:TXD–
5:RXD–
6:COM
EXAMPLE DIGITAL INPUTS
SINKING LOGIC
SOURCING LOGIC
DIGITAL INPUT 1
DIGITAL INPUT 2
DIGITAL INPUT 3
DIGITAL INPUT 4
COM
SNK/SRC
+24V

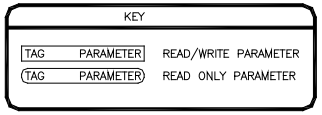
MICROMANAGER MM3010-MBS
SOFTWARE BLOCK DIAGRAM

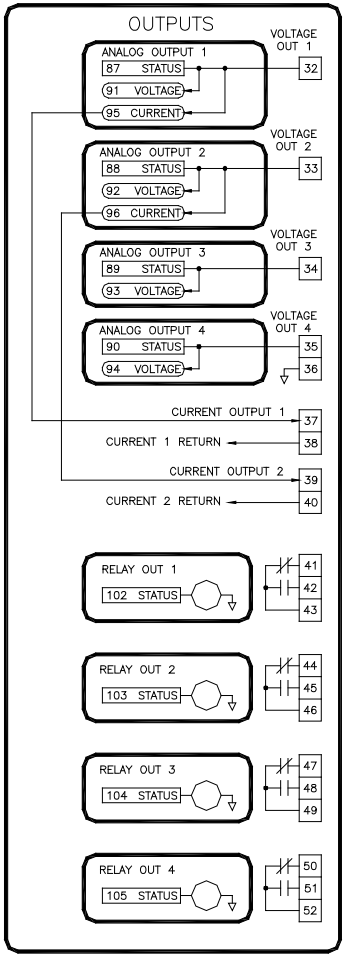












DRAWN BY: BKP	DATE: 5/15/08	CAROTRON Driven by Excellence	
APPROVED BY:	DATE:	HEATH SPRINGS, SC TEL 803-286-8614 FAX 803-286-6063	
TOLERANCES: ± 2 DEC. PL. = .010" 3 DEC. PL. = .005"		TITLE: MM3010-MBS MODBUS RTU SLAVE SOFTWARE BLOCK DIAGRAM	
SCALE:			
DRAWING NUMBER: D13596	REV. A	SH. 1 OF 1	

8 Standard Terms & Conditions of Sale

1. General
The Standard Terms and Conditions of Sale of Carotron, Inc. (hereinafter called "Company") are set forth as follows in order to give the Company and the Purchaser a clear understanding thereof. No additional or different terms and conditions of sale by the Company shall be binding upon the Company unless they are expressly consented to by the Company in writing. The acceptance by the Company of any order of the Purchaser is expressly conditioned upon the Purchaser's agreement to said Standard Terms and Conditions. The acceptance or acknowledgement, written, oral, by conduct or otherwise, by the Company of the Purchaser's order shall not constitute written consent by the Company to addition to or change in said Standard Terms and Conditions.

2. Prices
Prices, discounts, allowances, services and commissions are subject to change without notice. Prices shown on any Company published price list and other published literature issued by the Company are not offers to sell and are subject to express confirmation by written quotation and acknowledgement. All orders of the Purchaser are subject to acceptance, which shall not be effective unless made in writing by an authorized Company representative at its office in Heath Springs, S.C. The Company may refuse to accept any order for any reason whatsoever without incurring any liability to the Purchaser. The Company reserves the right to correct clerical and stenographic errors at any time.

3. Shipping dates
Quotation of a shipping date by the Company is based on conditions at the date upon which the quotation is made. Any such shipping date is subject to change occasioned by agreements entered into previous to the Company's acceptance of the Purchaser's order, governmental priorities, strikes, riots, fires, the elements, explosion, war, embargoes, epidemics, quarantines, acts of God, labor troubles, delays of vendors or of transportation, inability to obtain raw materials, containers or transportation or manufacturing facilities or any other cause beyond the reasonable control of the Company. In no event shall the Company be liable for consequential damages for failure to meet any shipping date resulting from any of the above causes or any other cause.

In the event of any delay in the Purchaser's accepting shipment of products or parts in accordance with scheduled shipping dates, which delay has been requested by the Purchaser, or any such delay which has been caused by lack of shipping instructions, the Company shall store all products and parts involved at the Purchaser's risk and expense and shall invoice the Purchaser for the full contract price of such products and parts on the date scheduled for shipment or on the date on which the same is ready for delivery, whichever occurs later.

4. Warranty
The Company warrants to the Purchaser that products manufactured or parts repaired by the Company, will be free, under normal use and maintenance, from defects in material and workmanship for a period of one (1) year after the shipment date from the Company's factory to the Purchaser. The Company makes no warranty concerning products manufactured by other parties.

As the Purchaser's sole and exclusive remedy under said warranty in regard to such products and parts, including but not limited to remedy for consequential damages, the Company will at its option, repair or replace without charge any product manufactured or part repaired by it, which is found to the Company's satisfaction to be so defective; provided, however, that (a) the product or part involved is returned to the Company at the location designated by the Company, transportation charges prepaid by the Purchaser; or (b) at the Company's option the product or part will be repaired or replaced in the Purchaser's plant; and also provided that Cc) the Company is notified of the defect within one (1) year after the shipment date from the Company's factory of the product or part so involved.

The Company warrants to the Purchaser that any system engineered by it and started up under the supervision of an authorized Company representative will, if properly installed, operated and maintained, perform in compliance with such system's written specifications for a period of one (1) year from the date of shipment of such system.

As the Purchaser's sole and exclusive remedy under said warrant in regard to such systems, including but not limited to remedy for consequential damages, the Company will, at its option, cause, without charges any such system to so perform, which system is found to the Company's satisfaction to have failed to so perform, or refund to the Purchaser the purchase price paid by the Purchaser to the Company in regard thereto; provided, however, that (a) Company and its representatives are permitted to inspect and work upon the system involved during reasonable hours, and (b) the Company is notified of the failure within one (1) year after date of shipment of the system so involved.

The warranties hereunder of the Company specifically exclude and do not apply to the following:

a. Products and parts damaged or abused in shipment without fault of the Company.

b. Defects and failures due to operation, either intentional or otherwise, (l) above or beyond rated capacities, (2) in connection with equipment not recommended by the Company, or (3) in an otherwise improper manner.

c. Defects and failures due to misapplication, abuse, improper installation or abnormal conditions of temperature, humidity, abrasives, dirt or corrosive matter.

d. Products, parts and systems which have been in any way tampered with or altered by any party other than an authorized Company representative.

e. Products, parts and systems designed by the Purchaser.

f. Any party other than the Purchaser.

The Company makes no other warranties or representation, expressed or implied, of merchantability and of fitness for a particular purpose, in regard to products manufactured, parts repaired and systems engineered by it.

5. Terms of payment
Standard terms of payment are net thirty (30) days from date of the Company invoice. For invoice purposed, delivery shall be deemed to be complete at the time the products, parts and systems are shipped from the Company and shall not be conditioned upon the start up thereof. Amounts past due are subject to a service charge of 1.5% per month or fraction thereof.

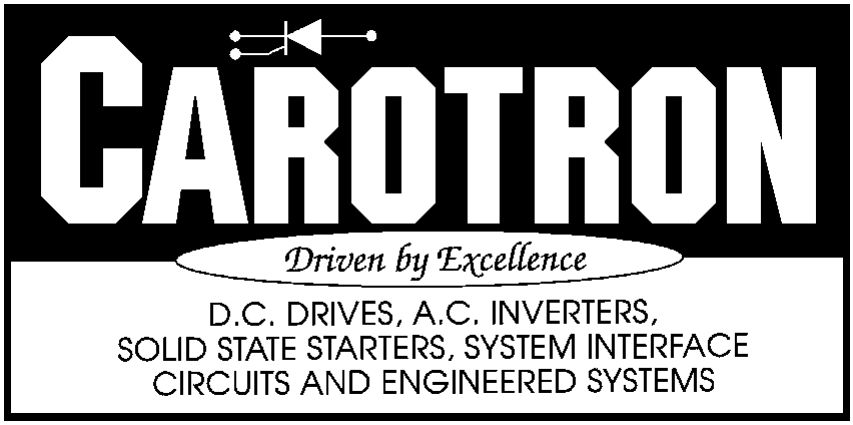
6. Order cancellation
Any cancellation by the Purchaser of any order or contract between the Company and the Purchaser must be made in writing and receive written approval of an authorized Company representative at its office in Heath Springs, S.C. In the event of any cancellation of an order by either party, the Purchaser shall pay to the Company the reasonable costs, expenses, damages and loss of profit of the Company incurred there by, including but not limited to engineering expenses and expenses caused by commitments to the suppliers of the Company's subcontractors, as determined by the Company.

7. Changes
The Purchaser may, from time to time, but only with the written consent of an authorized Company representative, make a change in specifications to products, parts or systems covered by a purchase order accepted by the company. In the event of any such changes, the Company shall be entitled to revise its price and delivery schedule under such order.

8. Returned material
If the Purchaser desires to return any product or part, written authorization thereof must first be obtained from the Company which will advise the Purchaser of the credit to be allowed and restocking charges to be paid in regard to such return. No product or part shall be returned to the Company without a "RETURNTAG" attached thereon which has been issued by the Company.

9. Packing
Published prices and quotations include the Company's standard packing for domestic shipment. Additional expenses for special packing or overseas shipments shall be paid by the Purchaser. If the Purchaser does not specify packing or accepts parts unpacked, no allowance will be made to the Purchaser in lieu of packing.

10. Standard transportation policy
Unless expressly provided in writing to the contrary, products, parts and systems are sold f.o.b. first point of shipment. Partial shipments shall be permitted, and the Company may invoice each shipment separately. Claims for non-delivery of products, parts and systems, and for damages thereto must be filed with the carrier by the Purchaser. The Company's responsibility therefor shall cease when the carrier signs for and accepts the shipment.



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