ACL Manufacturing
A Division of ClearRushCo

Modbus Manual

for the

CSC400 Safety Combustion Controller

V 1.2

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Introduction and Summary

The CSC400 Controllers are able to communicate remotely with Modbus Master Devices. A Modbus Master Device may be a Programmable Logic Controller, a PC, or another device. The CSC400 Controller is a Modbus Slave Device that implements the Modbus RTU protocol on an RS-485, half-duplex, physical connection.

The CSC400 has a hardware revision of 1D and firmware version 00.02.10 (minimum). The registers have been updated to show those available in firmware version 00.02.46.

The default Modbus communication parameters are 9600 baud, 8 data bits, no parity bits, one stop bit ("8N1"), Modbus Slave ID (Modbus address) 2.

CSC400 Controller Modbus Quick Summary	
Protocol	RTU
Physical Connection	RS485, half-duplex
Hardware Revision	1D
Firmware Version (minimum)	00.02.10
Default Settings	
Baud rate	9600
Number of data bits	8
Parity bit setting	None
Stop bits	1
Slave ID (Modbus Address)	2

THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS1 DIVISION 2, GROUPS A,B,C & D OR NONHAZARDOUS LOCATIONS ONLY

WARNING - EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR THE SUITABILITY FOR CLASS 1 DIVISION 2

WARNING: EXPOSURE TO SOME CHEMICALS MAY DEGRADE THE SEALING PROPERTIES OF MATERIALS USED IN THE FOLLOWING DEVICES:

Twelve-position DIP switch S1
Four-position, half-pitch DIP switch SW8
Eight-position DIP switch SW2

Additional Documents

The following additional documents for the CSC400 Combustion Safety Controller are available.

Document Filename	Document Description
CSC400_Rev_1D_Installation_Manual1_for_FW_v00_02_35_v2_16.pdf	CSC400 installation information and quickstart instructions.
CSC400_Modbus_SD_Log_Reading_Instructions.pdf	CSC400 Shutdown log readback instructions

Definitions, Acronyms, and Abbreviations

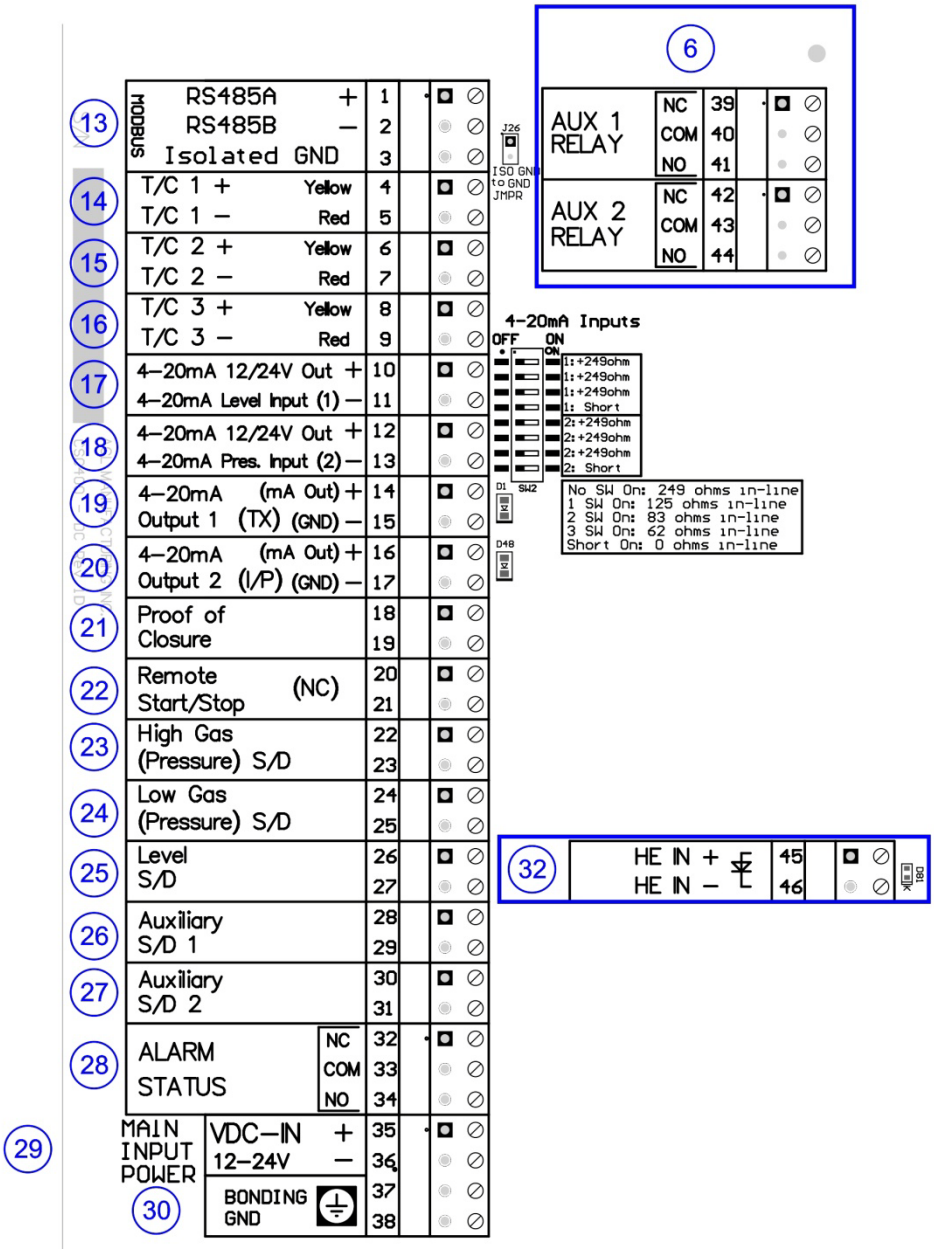
Acronym	Description
IGN1	Igniter 1 - Terminal group (Power, Alarm, Valve, Ground, Pilot Ground) used to control Ignition Module attached to terminals 58 through 62. Corresponding solenoids are Temperature Main, Main, and Pilot on terminals 63 through 68.
IGN2	Igniter 2 - Terminal group (Power, Alarm, Valve, Ground, Pilot Ground) used to control Ignition Module attached to terminals 47 through 51. Corresponding solenoids are Temperature Main, Main, and Pilot on terminals 52 through 57.
POC	Proof of Closure

Quickstart Installation Procedure

CSC400 Controller - Modbus

> The Quickstart Installation Instructions assumes the user has some familiarity with Modbus and Modbus cabling and communications.

Figure 1 – Input and Control Connections, Front-Top View



Programming a New Modbus Slave ID

1) A new Modbus Slave ID can be programmed via the Modbus Settings menu on the CSC400.

Modbus/RS-485 Cable Connections – Field Installations

Special Notes
Ensure that only industrial-rated equipment is used for field installations, with appropriate measures for handling noisy environments.

If using a PC with USB-to-RS485 connectivity for field installations, use an industrial-rated USB hub (preferably one with a metal case) for connecting the PC to the USB-to-RS485 cable.

Refer to Appendix C for additional Modbus cabling technical details.

Cabling

Connect a cable from a PLC (Programmable Logic Controller) or a PC to the 3-pin terminal strip of the CSC400 labeled "Modbus", observing proper connections:

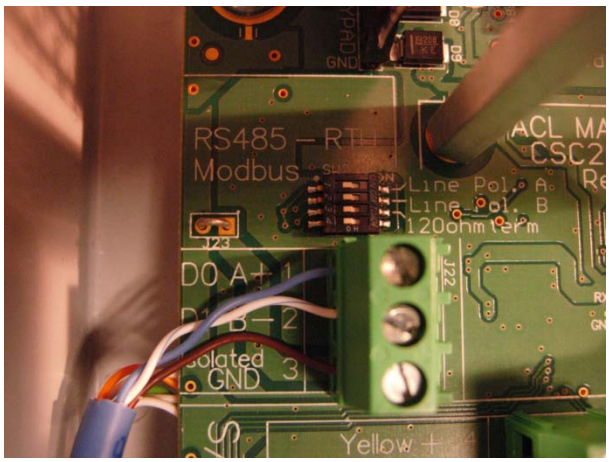
- The RS-485 standard suggests using twisted pair type cables (CAT5E or a shielded twisted pair with ground) for connecting devices together. This is definitely a requirement for longer cable runs (25m to 1000m) and for use in noisy environments like industrial or commercial installations.

- The RS485 signal naming convention used in this document and by many RS485 transceiver vendors is reversed from what the EIA/TIA-485 specification states:

CSC400 Modbus/RS485 Documentation	EIA/TIA-485 Naming Convention	Modbus Specification Name	Description
A (“RS485 A +” or "D0 A+")	B	D1	Non-Inverting, Transceiver Terminal 1, V1 voltage (V1 > V0 for binary 1 (OFF) state
B (“RS485 B –” or "D1 B-")	A	D0	Inverting, Transceiver Terminal 0, V0 voltage (V0 > V1 for binary 0 (ON) state
Isolated GND (or common GND)	C	Common	Signal and Optional Power Supply common ground

- Ensure that the “Isolated Ground” terminals are all attached together on all RS485 devices on the bus. This ground should be connected to earth ground at one point along the bus, preferably at the Master.

Figure 2 - Example CAT5E Cable Connection



- If using a CAT5E (or similar) cable with unused wires, do not leave them "floating". Connect these wires at one point on the cable to the ground (or "Isolated GND") terminal at the CSC400, or at the master's ground terminal.

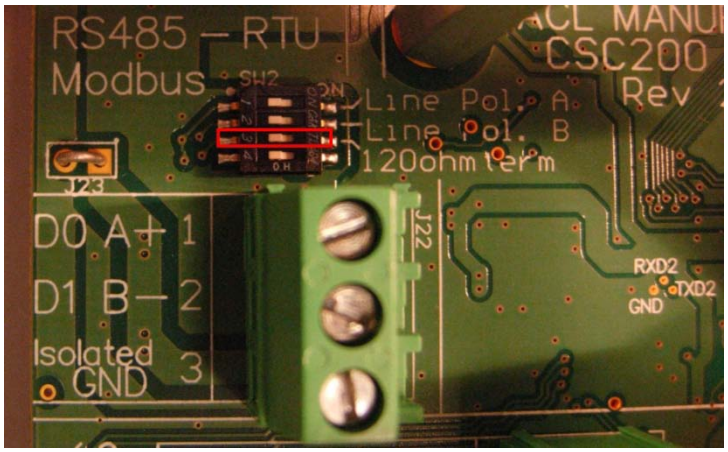
- A USB-to-RS485 cable may also have unused wires if the provided Terminator resistor wires are not used (the FTDI Chip cable as an example). These should be connected to ground as well, to reduce noise propagation.

Termination

An RS-485 bus should only be terminated at each end of the cable (at each device at the end of the cable). No other devices in-between the two devices at each end should have termination resistors installed or enabled. If there are 20 devices on an RS-485 bus in a daisy-chain, the 120 ohm termination resistors should only be enabled at the first device and at the 20th device.

The CSC400 Controller has a 4-pin DIP switch with the third switch from the top labeled "120ohm term". This can be used to connect a built-in 120 ohm resistor. Simply push the third DIP switch to the right and the 120ohm termination resistor will be connected.

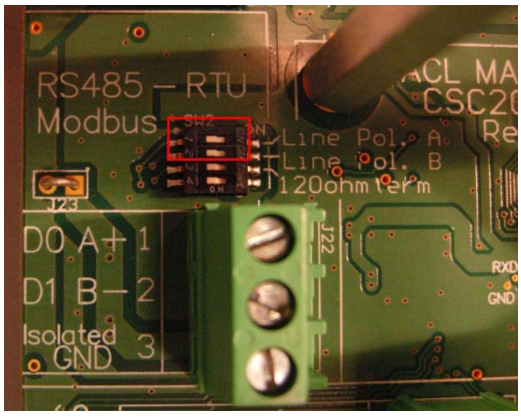
Figure 3 - 120 ohm Termination Resistor DIP Switch



Line Polarization

If Line Polarization is not available on the Master device and is required for the RS-485 bus in this installation, two "Line Polarization" DIP switches on the CSC400 Controller are available. To enable the Line Polarization terminations, move them to the right (towards the "Line Pol…" text) as shown in the picture below (Figure 4). If the DIP switches are moved towards the left, the Line Polarization terminations are removed from the RS-485 bus on this CSC400 device.

Figure 4 – Line Polarization DIP Switches



"Line Polarization" enables a pullup resistor on the "Data A +" signal and a pulldown resistor on the "Data B –" signal. It ensures that the bus is put into a known state with the "Data A +" signal High and the "Data B -" signal Low.

Line Polarization should only be enabled on one device on the RS485 bus, if necessary. Usually this is done at the end of the bus where the master device resides.

Isolated (or Common) Ground

The "Isolated Ground" terminal on each CSC400 Controller is isolated from the onboard CSC400 ground. This isolated ground connection should be used to connect all common ground connections on all RS-485 devices on the bus. This common ground should be connected to earth or protective ground at one end of the RS-485 cable only (preferably), usually at the master device.

Due to the potential for large amounts of noise to be conducted onto the RS485 cable, an option is provided to connect the RS485 isolated ground to the CSC400 earth ground to shunt noise away locally instead of at the Modbus master. A solid ground connection should be made between a CSC400 earth ground terminal to an earth ground external to the CSC400 using a minimum 16AWG wire.

Commonly Used CSC400 Modbus Registers

Notes:
- SCADAPack Register Addresses are listed for reference when programming SCADAPack PLC units.
- See Appendix A - Full CSC400 Modbus Registers List for additional registers and specific details about reading and writing registers.

Function Code 0x01 - Read Coils

Function used to read the state of each relay. Read Coil function code 0x01 can read all relay coils in two bytes.

SCADAPack Register Address	Coil #	Coil Byte	Coil Bit	Modbus Coil Address	Description	Type	Notes
1	1	0	0	0	"AUX1 Relay" control relay	Auxiliary Control relay	Dry contacts, max 0.12A @ 30VDC 1 = relay ON
2	2	0	1	1	"AUX2 Relay" control relay	Auxiliary Control relay	Dry contacts, max 0.12A @ 30VDC 1 = relay ON
3	3	0	2	2	IGN1 Pilot solenoid relay	Solenoid relay	1 = relay ON
4	4	0	3	3	IGN1 Main solenoid relay	Solenoid relay	1 = relay ON
5	5	0	4	4	Alarm due to external shutdown	Control relay	**0 = relay OFF = Alarm condition. 1 = relay ON, no Alarm**
6	6	0	5	5	Reserved		
7	7	0	6	6	IGN1 Proof of Closure/Ignitor relay	Internal Control Relay	1 = relay ON
8	8	0	7	7	IGN1 Temperature Main solenoid relay	Solenoid relay	1 = relay ON
9	9	1	0	8	IGN2 Pilot solenoid relay	Solenoid relay	1 = relay ON
10	10	1	1	9	IGN2 Main solenoid relay	Solenoid relay	1 = relay ON
11	11	1	2	10	IGN2 Temperature Main solenoid relay	Solenoid relay	1 = relay ON
12	12	1	3	11	IGN2 Proof of Closure/Ignitor relay	Internal Control Relay	1 = relay ON

13	13	1	4	12	Alarm relay - mirrors Alarm/Status contacts	Control relay	**0 = relay OFF = Alarm condition. 1 = relay ON, no Alarm**

Function Code 0x02 - Read Discrete Inputs

This Function is used to read the state of each input. 1 = ON, 0 = OFF (unless otherwise stated)

SCADA Pack Register Address	Input #	Modbus Discrete Input Address	Inputs Byte	Input Bit	Description	Notes
10001	1	0	0	0 (LSB)	Igniter 1 Alarm input	1 = Alarm signal high (Alarm indicated)
10002	2	1	0	1	Igniter 1 Valve input	1 = Valve signal high
10003	3	2	0	2	IGN1 Main solenoid	1 = Main solenoid is on
10004	4	3	0	3	IGN1 Pilot solenoid	1 = Pilot solenoid is on
10005	5	4	0	4	IGN1 T/Main solenoid	1 = T/Main solenoid is on
10006	6	5	0	5	Reserved	
10007	7	6	0	6	POC/IGN1 relay output	1 = POC/IGN1 relay output is High (12VDC present)
10008	8	7	0	7 (MSB)	POC minus terminal	1 = POC "minus" terminal is High (12VDC present)

Function Code 0x03 - Read Holding Registers

Holding registers are 16-bit values (2 bytes), Register bytes are read back as MSB then LSB

SCADA Pack Register Address	Register #	Modbus Holding Register Address	Description	Notes
40001	1	0	TC1 temp setpoint (deg C)	IGN1 (ignitor 1) TC1 setpoint, Signed value: -60 = 0xFFC4, 100 = 0x0064
40002	2	1	TC2 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
40003	3	2	TC1 temp setpoint (deg F)	IGN1 (ignitor 1) TC1 setpoint, Signed value: -76 = 0xFFB4, 212 = 0x00D4
40004	4	3	TC2 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
40050	50	49	TC3 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
40051	51	50	TC3 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
40149	149	148	TC1 temp setpoint (deg C), IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	Writing a value to TC1, IGN2 (if firmware enabled for separate IGN1/2 setpoints) in degrees C, also writes to the TC1 degrees F register (after conversion). Signed value: -60 = 0xFFC4, 100 = 0x0064
40150	150	149	TC1 temp setpoint (deg F) , IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	Writing a value to TC1, IGN2 (if firmware enabled for separate IGN1/2 setpoints) in degrees F, also writes to the TC1 degrees C register (after conversion). Signed value: -76 = 0xFFB4, 212 = 0x00D4

Function Code 0x04 - Read Input Registers

Input registers are 16-bit values (2 bytes), Register bytes are read back as MSB then LSB

SCADA Pack Register Address	Register #	Modbus Inputs Register Address	Description	Notes
30001	1	0	TC1 current temp (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
30002	2	1	TC2 current temp (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
30003	3	2	TC1 current temp (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
30004	4	3	TC2 current temp (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
30005	5	4	TC3 current temp (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
30006	6	5	TC3 current temp (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4

Function Code 0x05 – Write Single “Coil” (or Setting)

The individual "coils" can't actually be written to, they're influenced by the temperature - Remote Stop and Remote Start are allowed though.
Remote Stop will turn off all relays in the CSC400. CSC400 can only be started again by a Remote Start command, or by pressing the Stop button, then the Start button.

SCADAPack Register Address	Coil #	Modbus Write Coil Address	Description	Notes
1	1	0	AUX1 Control Relay	Write access only allowed when the Modbus control option is selected in the AUX1 Relay Settings (Holding Register 140)
2	2	1	AUX2 Control Relay	Write access only allowed when the Modbus control option is selected in the AUX1 Relay Settings (Holding Register 144)
3 - 16	3 - 16	2 - 15	(No direct write access to relays)	
17	17	16	Increment TC1 IGN1 setpoint	ON = increment TC1 IGN1 setpoint, OFF = no effect
18	18	17	Decrement TC1 IGN1 setpoint	ON = increment TC1 IGN1 setpoint, OFF = no effect
19	19	18	Increment TC2 setpoint	ON = increment TC2 setpoint, OFF = no effect
20	20	19	Decrement TC2 setpoint	ON = increment TC2 setpoint, OFF = no effect
21	21	20	Increment TC3 setpoint	ON = increment TC3 setpoint, OFF = no effect
22	22	21	Decrement TC3 setpoint	ON = increment TC3 setpoint, OFF = no effect
23	23	22	Remote Stop	ON = Stop, OFF = no effect
24	24	23	Remote Start	ON = Start, OFF = no effect
25	25	24	Increment TC1, IGN2 setpoint (if firmware enabled for separate IGN1/2 setpoints)	ON = increment TC1, IGN2 setpoint, OFF = no effect
26	26	25	Decrement TC1, IGN2 setpoint (if firmware enabled for separate	ON = decrement TC1, IGN2 setpoint, OFF = no effect

			IGN1/2 setpoints)	

Notes:

- Write Single "Coil" (or setting) function code 0x05 can control the AUX1/2 relay (if that option is selected for aUX1/2 Relay control), increment/decrement the setpoint temperatures of either thermocouple, and can also trigger a Remote Stop or Remote Start command.
- "0xFF00" (or 65280 in decimal) turns a "coil" ON, "0x0000" turns a coil "OFF"
- For our "coils" or settings, 0x0000 or OFF, has no effect on the Setpoints or Remote Stop/Start settings.
- Remote Stop disables all power going to ignition module and closes all three valve solenoids for both burners
- Remote Stop can be cleared by a physical toggling of the Remote Start/Stop power rung or by pressing Stop button, then Start button
- Remote Stop can also be cleared by receiving a Modbus message turning Remote Start ON
- Remote Start enables the CSC400 to be turned on
- Remote Start can be interrupted if the overlay is unplugged, if Remote Start/Stop is open, if any Shutdown power rung is open, or if POC is still open
- Remote Start can also be cleared by receiving a Modbus message turning Remote Stop ON (ie: sending a Remote Stop message)

Function Code 0x06 - Write Holding Registers

Holding registers are 16-bit values (2 bytes), Register bytes are written as MSB then LSB

SCADA Pack Register Address	Register #	Modbus Holding Register Address	Description	Notes
40001	1	0	TC1 IGN1 temp setpoint (deg C)	Writing a value to TC1, IGN1 in degrees C, also writes to the TC1 degrees F register (after conversion)
40002	2	1	TC2 temp setpoint (deg C)	Writing a value to TC2 in degrees C, also writes to the TC2 degrees F register (after conversion)
40003	3	2	TC1 IGN1 temp setpoint (deg F)	Writing a value to TC1, IGN1 in degrees F, also writes to the TC1 degrees C register (after conversion)
40004	4	3	TC2 temp setpoint (deg F)	Writing a value to TC2 in degrees F, also writes to the TC2 degrees C register (after conversion)
40050	50	49	TC3 temp setpoint (deg C)	Writing a value to TC3 in degrees C, also writes to the TC3 degrees F register (after conversion)
40051	51	50	TC3 temp setpoint (deg F)	Writing a value to TC3 in degrees F, also writes to the TC3 degrees C register (after conversion)
40149	149	148	TC1 temp setpoint (deg C), IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	Writing a value to TC1, IGN2 (if code enabled for separate IGN1/2 setpoints) in degrees C, also writes to the TC1 degrees F register (after conversion)
40150	150	149	TC1 temp setpoint (deg F) , IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	Writing a value to TC1, IGN2 (if code enabled for separate IGN1/2 setpoints) in degrees F, also writes to the TC1 degrees C register (after conversion)

Appendix A - Full CSC400 Modbus Registers List

Supported Modbus Function Code Commands for the CSC400

Function Code		Sub-Function Code		Function Name	Length (bits)	Description of Use With CSC400
(Dec)	(Hex)	(Dec)	(Hex)			
1	0x01			Read Coils	1	Used to read the state of each relay
2	0x02			Read Discrete Inputs	1	Used to read the state of each input
3	0x03			Read Holding Registers	16	Used to read the holding registers
4	0x04			Read Input Registers	16	Used to read the input registers
5	0x05			Write Single “Coil” (or setting)	1	Used to increment/decrement temperature setpoint and controls Remote Start/Stop
6	0x06			Write Single Holding Register	16	Used to write values to individual holding registers for setup or control
8	0x08			Diagnostics		
		0	0x00	Return Query Data (loopback)		Echoes the request back to the Master
		1	0x01	Restart Communications Option		Restart communications port and brings device out of Listen Only mode if currently in it
		4	0x04	Force Listen Only Mode		Device will not respond to requests if put in this mode
		10	0x0A	Clear Counters and Diagnostic Register		Clear Counters and Diagnostic Register
		11	0x0B	Return Bus Message Count		Returns number of messages on the bus since last restart, clear counters operation, or powerup (even if not addressed to this device)
		12	0x0C	Return Bus Communication Error Count		Returns number of CRC errors since last restart, clear counters operation, or powerup
		13	0x0D	Return Bus Exception Error Count		Returns number of exception responses sent back to the Master since last restart, clear counters operation, or powerup
		14	0x0E	Return Slave Message Count		Returns number of messages addressed to this device since last restart, clear counters operation, or powerup
43	0x2B	14	0x0E	Read Device Identification		Allows reading the identification and additional information relative to the physical and functional description of the CSC400

Notes:

- “Length” refers to the number of bits used for each value. For example, a coil is 1 bit in length (either a zero or a one) whereas a Holding Register is 16 bits in length (values are from 0 to 65535 (0xFFFF))

Specific Modbus Function Code Register Details

Notes:
- SCADAPack Register Addresses are listed for reference when programming SCADAPack PLC units.

Function Code 0x01 - Read Coils

Function used to read the state of each relay. Read Coil function code 0x01 can read all relay coils in two bytes.

SCADAPack Register Address	Coil #	Coil Byte	Coil Bit	Modbus Coil Address	Description	Type	Notes
1	1	0	0	0	"AUX1 Relay" control relay	Auxiliary Control relay	Dry contacts, max 0.12A @ 30VDC 1 = relay ON
2	2	0	1	1	"AUX2 Relay" control relay	Auxiliary Control relay	Dry contacts, max 0.12A @ 30VDC 1 = relay ON
3	3	0	2	2	IGN1 Pilot solenoid relay	Solenoid relay	1 = relay ON
4	4	0	3	3	IGN1 Main solenoid relay	Solenoid relay	1 = relay ON
5	5	0	4	4	Alarm due to external shutdown	Control relay	**0 = relay OFF = Alarm condition. 1 = relay ON, no Alarm**
6	6	0	5	5	Reserved		
7	7	0	6	6	IGN1 Proof of Closure/Ignitor relay	Internal Control Relay	1 = relay ON
8	8	0	7	7	IGN1 Temperature Main solenoid relay	Solenoid relay	1 = relay ON
9	9	1	0	8	IGN2 Pilot solenoid relay	Solenoid relay	1 = relay ON
10	10	1	1	9	IGN2 Main solenoid relay	Solenoid relay	1 = relay ON
11	11	1	2	10	IGN2 Temperature Main solenoid relay	Solenoid relay	1 = relay ON
12	12	1	3	11	IGN2 Proof of Closure/Ignitor relay	Internal Control Relay	1 = relay ON
13	13	1	4	12	Alarm relay - mirrors Alarm/Status contacts	Control relay	**0 = relay OFF = Alarm condition. 1 = relay ON, no Alarm**

Notes:
- Read Coil function code 0x01 can read all relay coils in one byte.

Recommended Modbus Read Coils request message sent to CSC400 (PDU, protocol data unit):

0x01 0x00 0x00 0x00 0x08

Function - Read Coils	0x01
Starting Address Hi	0x00
Starting Address Lo	0x00
Quantity of Outputs Hi	0x00
Quantity of Outputs Lo	0x08

Modbus Read Coils response message sent back to Master from CSC400 (PDU, protocol data unit):

0x01 0x01 0xXX

Function - Read Coils	0x01
Byte Count	0x01
Output (Coil) Status	0xXX where XX is the byte holding the current status of the coils in the same configuration as above

Function Code 0x02 - Read Discrete Inputs

Function used to read the state of each input
1 = ON, 0 = OFF (unless otherwise stated)

SCADA Pack Register Address	Input #	Modbus Discrete Input Address	Inputs Byte	Input Bit	Description	Notes
10001	1	0	0	0 (LSB)	Igniter 1 Alarm input	1 = Alarm signal high (Alarm indicated)
10002	2	1	0	1	Igniter 1 Valve input	1 = Valve signal high
10003	3	2	0	2	IGN1 Main solenoid	1 = Main solenoid is on
10004	4	3	0	3	IGN1 Pilot solenoid	1 = Pilot solenoid is on
10005	5	4	0	4	IGN1 T/Main solenoid	1 = T/Main solenoid is on
10006	6	5	0	5	Reserved	
10007	7	6	0	6	POC/IGN1 relay output	1 = POC/IGN1 relay output is High (12VDC present)
10008	8	7	0	7 (MSB)	POC minus terminal	1 = POC "minus" terminal is High (12VDC present)
10009	9	8	1	0 (LSB)	High Gas Shutdown input	1 = Shutdown input is High (12VDC present, shutdown sensor not tripped)
10010	10	9	1	1	Remote Stop/Start input	1 = Remote Stop/Start switch is On/Closed (12VDC present)
10011	11	10	1	2	HT input: AUX2 SD terminal (terminal 31) input (output of TC2 "R2" relay)	1 = High Temp R2 relay output is High (12VDC is present, not in High Temp shutdown), 0 = high temp shutdown
10012	12	11	1	3	Output of TC1 "R1" relay (input to POC relay)	1 = "Low" Temp R1 relay output is High (12VDC is present), 0 = TC1 temp is in shutdown (if in Intermittent Pilot mode)
10013	13	12	1	4	PWR fail condition. On upon powerup. Will be on if latched out.	1 = Latch is on presently
10014	14	13	1	5	PWR fail latch condition	1 = Latch is on presently
10015	15	14	1	6	HT/HT latch condition	1 = Latch is on presently
10016	16	15	1	7 (MSB)	High Gas SD/SD latch condition	1 = Latch is on presently

10017	17	16	2	0 (LSB)	Thermocouple 1 open/fault	1 = TC fault, 0 = no fault
10018	18	17	2	1	Thermocouple 2 open/fault	1 = TC fault, 0 = no fault
10019	19	18	2	2	Modbus Remote Stop condition	1 = Modbus Remote Stop is active (CSC400 is stopped via Modbus)
10020	20	19	2	3	Level Shutdown input	1 = Level Shutdown input is High (12VDC present, shutdown sensor not tripped)
10021	21	20	2	4	IGN1 Pilot Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10022	22	21	2	5	IGN1 Main Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10023	23	22	2	6	IGN1 TMain Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10024	24	23	2	7 (MSB)	Reserved	
10025	25	24	3	0 (LSB)	"Stop"/R9 relay output	1 = R9 "Stop" relay is on (start of 12VDC to HT relay, then to SDs)
10026	26	25	3	1	Thermocouple 3 open/fault	1 = TC fault, 0 = no fault
10027	27	26	3	2	AUX2 SD/SD latch condition	1 = Latch is on presently
10028	28	27	3	3	AUX1 SD/SD latch condition	1 = Latch is on presently
10029	29	28	3	4	Level SD/SD latch condition	1 = Latch is on presently
10030	30	29	3	5	Low Gas SD/SD latch condition	1 = Latch is on presently
10031	31	30	3	6	4-20mA Level (1) Input SD/SD latch condition	1 = Latch is on presently
10032	32	31	3	7 (MSB)	AUX2 Shutdown input	1 = AUX2 Shutdown input is High (12VDC present, SD not tripped)
10033	33	32	4	0 (LSB)	AUX1 Shutdown input	1 = AUX1 Shutdown input is High (12VDC present, SD not tripped)
10034	34	33	4	1	Low Gas Shutdown input	1 = Low Gas Shutdown input is High (12VDC present, SD not tripped)
10035	35	34	4	2	Unplug detect signal	1 = Overlay is removed (Alarm condition), 0 = overlay is present
10036	36	35	4	3	Stop Button input	1 = Stop button is high, not pressed, 0 = button is pressed
10037	37	36	4	4	Start Button input	1 = Start button is high, not pressed, 0 = button is pressed
10038	38	37	4	5	CSC400 System State	1 = System On, 0 = System Off
10039	39	38	4	6	Reserved	
10040	40	39	4	7 (MSB)	4-20mA Pressure (2) Input SD/SD latch condition	1 = Latch is on presently

10041	41	40	5	0 (LSB)	Igniter 2 Alarm input	1 = Alarm signal high (Alarm indicated)
10042	42	41	5	1	Igniter 2 Valve input	1 = Valve signal high
10043	43	42	5	2	IGN2 Pilot Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10044	44	43	5	3	IGN2 Main Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10045	45	44	5	4	IGN2 TMain Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10046	46	45	5	5	IGN2 POC/Ignitor relay output measurement	1 = POC/IGN2 relay output is High (12VDC present)
10047	47	46	5	6	Low Temperature Alarm flag	1 = Low Temp Alarm has tripped, 0 = Low temp alarm has not tripped
10048	48	47	5	7 (MSB)	Low Temperature Shutdown flag	1 = Low Temp shutdown has tripped, 0 = Low temp shutdown has not tripped
					DIP Switches, first byte	
10049	49	48	6	0 (LSB)	Security Enable/Disable	1 = Enable security lockout feature, 0 = security lockout feature disabled
10050	50	49	6	1	OLED / VFD Display attached	1 = OLED display attached, 0 = VFD display attached
10051	51	50	6	2	DIP switch 3 (Spare 1)	1 = "OFF" side on silkscreen, 0 = "ON"
10052	52	51	6	3	DIP switch 4 (Spare 2)	1 = "OFF" side on silkscreen, 0 = "ON"
10053	53	52	6	4	DIP switch 5 (Spare 3)	1 = "OFF" side on silkscreen, 0 = "ON"
10054	54	53	6	5	DIP switch 6 (Spare 4)	1 = "OFF" side on silkscreen, 0 = "ON"
10055	55	54	6	6	DIP switch 7 (Spare 5)	1 = "OFF" side on silkscreen, 0 = "ON"
10056	56	55	6	7 (MSB)	DIP switch 8 (Spare 6)	1 = "OFF" side on silkscreen, 0 = "ON"
					DIP Switches, second byte	
10057	57	56	7	0 (LSB)	DIP switch 9 (Spare 7)	1 = "OFF" side on silkscreen, 0 = "ON"
10058	58	57	7	1	DIP switch 10 (Spare 8)	1 = "OFF" side on silkscreen, 0 = "ON"
10059	59	58	7	2	DIP switch 11 (Spare 9)	1 = "OFF" side on silkscreen, 0 = "ON"
10060	60	59	7	3	DIP switch 12 (Spare 10)	1 = "OFF" side on silkscreen, 0 = "ON"
10061	61	60	7	4	TC1 Temperature Log full	1 = full, 0 = not full yet
10062	62	61	7	5	TC2 Temperature Log full	1 = full, 0 = not full yet
10063	63	62	7	6	TC3 Temperature Log full	1 = full, 0 = not full yet
10064	64	63	7	7 (MSB)	SD Log full	1 = full, 0 = not full yet

10065	65	64	8	0 (LSB)	4-20mA Input 1 Lo Alarm (Level)	0 = no alarm, 1 = alarm (may or may not be in shutdown as well)
10066	66	65	8	1	4-20mA Input 1 Hi Alarm (Level)	0 = no alarm, 1 = alarm (may or may not be in shutdown as well)
10067	67	66	8	2	4-20mA Input 2 Lo Alarm (Pressure)	0 = no alarm, 1 = alarm (may or may not be in shutdown as well)
10068	68	67	8	3	4-20mA Input 2 Hi Alarm (Pressure)	0 = no alarm, 1 = alarm (may or may not be in shutdown as well)
10069	69	68	8	4	4-20mA Input 1 Fault (Level)	0 = no fault, 1 = fault (open)
10070	70	69	8	5	4-20mA Input 2 Fault (Pressure)	0 = no fault, 1 = fault (open)
10071	71	70	8	6	Reserved	
10072	72	71	8	7 (MSB)	Reserved	

Notes:

- Read discrete inputs function code 0x02 can read all inputs used for decision making and DIP switches.

Recommended Modbus Read Discrete inputs request message sent to CSC400 (PDU, protocol data unit):

0x02 0x00 0x00 0x00 0x28 (a read includes the reserved input bits)

Function - Read Discrete Inputs	0x02	
Starting Address Hi	0x00	
Starting Address Lo	0x00	
Quantity of Outputs Hi	0x00	
Quantity of Outputs Lo	0x28	

Modbus Read Discrete Inputs response message sent back to Master from CSC400 (PDU, protocol data unit):

0x02 0x05 0xXX 0xXX 0xXX 0xXX 0xXX

Function - Read Discrete Inputs	0x02	
Byte Count	0x05	
Inputs Status Byte 0	0xXX	Inputs byte 0
Inputs Status Byte 1	0xXX	Inputs byte 1
Inputs Status Byte 2	0xXX	Inputs byte 2
Inputs Status Byte 3	0xXX	Inputs byte 3 (DIP Switches, first byte)
Inputs Status Byte 4	0xXX	Inputs byte 4 (DIP Switches, second byte)

Function Code 0x03 - Read Holding Registers

Holding registers are 16-bit values (2 bytes)
Register bytes are read back as MSB then LSB

SCADA Pack Register Address	Register #	Modbus Holding Register Address	Description	Notes
40001	1	0	TC1 temp setpoint (deg C)	IGN1 (ignitor 1) TC1 setpoint, Signed value: -60 = 0xFFC4, 100 = 0x0064
40002	2	1	TC2 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
40003	3	2	TC1 temp setpoint (deg F)	IGN1 (ignitor 1) TC1 setpoint, Signed value: -76 = 0xFFB4, 212 = 0x00D4
40004	4	3	TC2 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
40005	5	4	Reserved	
40006	6	5	Reserved	
40007	7	6	Reserved	
40008	8	7	Reserved	
40009	9	8	Reset serial communication settings to default (9600, 8N1)	Reads as "0x0000" always
40010	10	9	Temperature log: Enable/Disable	"0x00" = disable Temp logging
				"0x01" = enable Temp logging but only when not in shutdown (Stop Button, HT, SD, Remote Stop, POC) (Default)
				"0x11" (17) = enable Temp logging, even when in shutdown (Stop Button, HT, SD, Remote Stop, POC)
40011	11	10	Reserved	
40012	12	11	Temperature log: Record Rate setting	(see Description of values in Function Code 0x06 - Write Single Holding Register)
40013	13	12	Temperature log: Reset log	Reads as "0x0000" always
40014	14	13	Temperature log: Total Count (Lower 16 bits) (Address 88 is the Upper 16-bits)	Holds the number of temperature measurements currently in each log (TC1, TC2, TC3). Max size is currently 512kB (256k entries, 16-bit data) Value range = 0 to 65535 (0 - 0xFFFF)
40015	15	14	Temperature log: Temperature Format	Value of "0" = store temp in currently selected format (eg: deg C if deg C selected by degC/degF menu setting)
				Value of "1" = save Temp in degrees Celsius
				Value of "2" = save Temp in degrees Fahrenheit
40016	16	15	Reserved	
40017	17	16	Shutdown log: Clear/Reset	Reads as "0x0000" always
40018	18	17	Shutdown log: Total Count (Lower 16-bits)	Holds the number of shutdown entries stored currently in the log. Max size is currently 65536 entries (time and date stamped). Value range = 0 to 65535 (0 - 0xFFFF)
40019	19	18	Shutdown log: Mask register (also see Mask register 2,	Selects the type of shutdowns to store in the shutdown log. Uses both bytes of holding

			holding register address 171)	register. A "1" enables the selected shutdown to be stored in the Shutdown log. Eg: Lower Byte = 0x13 (binary 0001 0011) only enables storing Power Fails, High Gas Shutdown power rung, and High-Temp shutdowns.
			Lower Byte	Bit 0: High-Temp Shutdown (TC2)
				Bit 1: High Gas Shutdown power rung
				Bit 2: Remote Start/Stop power rung
				Bit 3: Modbus remote stop
				Bit 4: Power Fails
				Bit 5: Stop Button
				Bit 6: IGN1 Flame Fails
				Bit 7: Dual TC1/2 difference SDs
			Upper Byte	Bit 0: AUX2 power rung
				Bit 1: AUX1 power rung
				Bit 2: Level power rung
				Bit 3: Low Gas power rung
				Bit 4: IGN2 Flame Fails
				Bit 5: TC3 High-Temp Shutdown
				Bit 6: 4-20mA Level Input SD
				Bit 7: 4-20mA Pressure Input SD
40020	20	19	Shutdown Count: TC1/2 Difference Shutdowns	SD: If TC1 & TC2 are different by more than 10°C, issue a latching shutdown
40021	21	20	Shutdown Count: IGN1 Flame Fails	All shutdown counts are 16-bits (range is 0 to 65535). All Shutdown Count registers will increment regardless of whether they are stored in the Shutdown Log.
40022	22	21	Shutdown Count: Stop Button	
40023	23	22	Shutdown Count: Power Fails	
40024	24	23	Shutdown Count: Modbus Remote Stops	
40025	25	24	Shutdown Count: Remote Stop/Start	
40026	26	25	Shutdown Count: High Gas Shutdown Power rung	
40027	27	26	Shutdown Count: High-Temp shutdowns (TC2)	
40028	28	27	Shutdown Count: Level Shutdown Power rung	
40029	29	28	Shutdown Counts: Clear/Reset	Reads as "0x0000" always
40030	30	29	TMain IGN1 time on, days	Indicates the number of total days the TMain IGN1 valve has been open/ON. Full result = days, hours, minutes
40031	31	30	TMain IGN1 time on, hours	Indicates the number of hours the TMain IGN1 valve has been open/ON.
40032	32	31	TMain IGN1 time on, minutes	Indicates the number of minutes the TMain IGN1 valve has been open/ON.

40033	33	32	TMain IGN1 time on, Clear/Reset	Clears/Zeros the TMain IGN1 ON time in all variables (days, hours, minutes), and in the EEPROM.
40034	34	33	Analog reading of Main Input Voltage	Analog reading is in mV (approx.) 12VDC on input = 2V 24VDC on input = 4V 30VDC on input = 5V (may clamp at 4096mV)
40035	35	34	Reserved	
40036	36	35	CSC400 Mode	0 = PI mode, 1 = HE mode, 2 = FI mode (default)
40037	37	36	IGN1 ON Timer value (PI mode)	Ignitor 1 timer on value (in seconds). (PI mode)
40038	38	37	IGN1 OFF Timer value (PI mode)	Ignitor 1 timer off value (in seconds). (PI mode)
40039	39	38	CSC400 System State	0 = System is off, 1 = System is on
40040	40	39	Clock Set: Year	0 - 99 (valid values)
40041	41	40	Clock Set: Month	1 - 12
40042	42	41	Clock Set: Day	1 - 31
40043	43	42	Clock Set: Hour	0 - 23
40044	44	43	Clock Set: Minute	0 - 59
40045	45	44	Clock Set: Seconds	0 - 59
40046	46	45	TMain IGN2 time on, days	Indicates the number of total days the TMain IGN2 valve has been open/ON. Full result = days, hours, minutes
40047	47	46	TMain IGN2 time on, hours	Indicates the number of hours the TMain IGN2 valve has been open/ON.
40048	48	47	TMain IGN2 time on, minutes	Indicates the number of minutes the TMain IGN2 valve has been open/ON.
40049	49	48	TMain IGN2 time on, Clear/Reset	Clears/Zeros the TMain IGN2 ON time in all variables (days, hours, minutes), and in the EEPROM.
40050	50	49	TC3 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
40051	51	50	TC3 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
40052	52	51	Shutdown Count: AUX 1 Shutdown Power rung	All shutdown counts are 16-bits (range is 0 to 65535). All Shutdown Count registers will increment regardless of whether they are stored in the Shutdown Log.
40053	53	52	Shutdown Count: AUX 2 Shutdown Power rung	
40054	54	53	Shutdown Count: Low Gas Shutdown Power rung	
40055	55	54	Shutdown Count: TC3 High-Temp Shutdowns	
40056	56	55	Shutdown Count: IGN2 Flame Fails	
40057	57	56	Shutdown Count: 4-20 Level Input	
40058	58	57	Shutdown Count: 4-20 Pressure Input	
40059	59	58	4-20mA Output 1 Select (0 - 7)	0 = output temp TC1

				1 = output temp TC2
				2 = output temp TC3
				3 = output Proportional valve using TC1 (4-20mA slow ramp transition with 10 degree band (+/- 5 degrees) around the selected setpoint temp)
				4 = output Proportional valve using TC2
				5 = output Proportional valve using TC3
				6 = Level In (4-20 In 1) retransmit (repeater/splitter mode)
				7 = Pressure In (4-20 In 2) retransmit (repeater/splitter mode)
40060	60	59	4-20mA Output 2 Select (0 - 7)	(see 4-20mA Output 1 Select above)
40061	61	60	Deadband setting, TC1 (TC1 IGN1 if firmware enabled for separate IGN1/2 setpoints for TC1)	1 - 5 degC, 2 - 10 degF
40062	62	61	Deadband setting, TC2	1 - 5 degC, 2 - 10 degF
40063	63	62	Deadband setting, TC3	1 - 5 degC, 2 - 10 degF
40064	64	63	Shutdown Latch mask register	Selects the Shutdowns to use as latched shutdowns ie: selected shutdowns set to "1" cause the system to latch out. The Stop/Start button or a Modbus Remote Start command are needed to restart the system
			Lower byte of Holding Register	Bit 0: High-Temp Latch
				Bit 1: High Gas Shutdown Latch
				Bit 2: Reserved
				Bit 3: Low Gas Shutdown Latch
				Bit 4: Power Fail Latch
				Bit 5: Level Shutdown Latch
				Bit 6: AUX1 Shutdown Latch
				Bit 7: AUX2 Shutdown Latch
			Upper Byte	Bit 0: 4-20 Input Level SD Latch
				Bit 1: 4-20 Input Pressure SD Latch
				Bit 2: TC3 High-Temp Latch
				Bit 3 - 7: Reserved
40065	65	64	IGN2 ON Timer value (PI mode)	Ignitor 2 timer on value (in seconds). (PI mode)
40066	66	65	IGN2 OFF Timer value (PI mode)	Ignitor 2 timer off value (in seconds). (PI mode)
40067	67	66	4-20mA Input 1 Format Select	0 = 4-20mA input, 1 = 1-5V input
40068	68	67	4-20mA Input 1 Lo Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input below Low trip point
40069	69	68	4-20mA Input 1 Hi Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input above High trip point
40070	70	69	4-20mA Input 1 SD on Low Alarm	0 = disabled, 1 = enable shutdown upon Lo Alarm

40071	71	70	4-20mA Input 1 SD on High Alarm	0 = disabled, 1 = enable shutdown upon Hi Alarm
40072	72	71	4-20mA Input 1 Custom Range Low Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40073	73	72	4-20mA Input 1 Custom Range High Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40074	74	73	4-20mA Input 1 Normal/Custom Range Low Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40075	75	74	4-20mA Input 1 Normal/Custom Range High Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40076	76	75	4-20mA Input 1 Custom Range Units	0 = mA (milliamps)
				1 = Volts
				2 = gallons
				3 = m3 (cubic meters)
				4 = psi
				5 = kPa
				6 = %
40077	77	76	4-20mA Input 1 Reserved	
40078	78	77	4-20mA Input 1 Deadband	0 - 20 (no units, lowest increment), eg. 20 = 0.20mA or 0.020V
40079	79	78	4-20mA Input 1 Reserved	
40080	80	79	4-20mA Input 1 Reserved	
40081	81	80	4-20mA Input 1 Reserved	
40082	82	81	4-20mA Input 1 Reserved	
40083	83	82	4-20mA Input 2 Format Select	0 = 4-20mA input, 1 = 1-5V input
40084	84	83	4-20mA Input 2 Lo Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input below Low trip point
40085	85	84	4-20mA Input 2 Hi Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input above High trip point
40086	86	85	4-20mA Input 2 SD on Low Alarm	0 = disabled, 1 = enable shutdown upon Lo Alarm
40087	87	86	4-20mA Input 2 SD on High Alarm	0 = disabled, 1 = enable shutdown upon Hi Alarm
40088	88	87	4-20mA Input 2 Custom Range Low Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40089	89	88	4-20mA Input 2 Custom Range High Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40090	90	89	4-20mA Input 2 Normal/Custom Range Low Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40091	91	90	4-20mA Input 2 Normal/Custom Range High Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40092	92	91	4-20mA Input 2 Custom Range Units	(see "4-20mA Input 1 Custom Range Units" section above)
40093	93	92	4-20mA Input 2 Reserved	
40094	94	93	4-20mA Input 2 Deadband	0 - 20 (no units, lowest increment), eg. 20 = 0.20mA or 0.020V

40095	95	94	4-20mA Input 2 Reserved	
40096	96	95	4-20mA Input 2 Reserved	
40097	97	96	4-20mA Input 2 Reserved	
40098	98	97	4-20mA Input 2 Reserved	
40099	99	98	Temperature log: Total Count (Upper 16-bits) (all 3 Temp logs are saved simultaneously)	Holds the upper 16-bits of the number of temperature measurements currently in each log (TC1, TC2, TC3). Max size is currently 512kB (256k entries, 16-bit data) Value range = 0 to 3 (max)
40100	100	99	Temperature log TC1 Entry Read Address (Low 16-bits)	Temp log entry number to start the next read cycle at. Max size is currently 512kB (256k entries = 262143 entries, 16-bit data) Temperature log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40101	101	100	Temperature log TC1 Entry Read Address (High 16-bits)	Value range = 0 to 3 (max) Max value is 3: Combined: 0x03FFFF = 262143 entries
40102	102	101	Temperature log TC2 Entry Read Address (Low 16-bits)	Temp log entry number to start the next read cycle at. Max size is currently 512kB (256k entries = 262143 entries, 16-bit data) Temperature log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40103	103	102	Temperature log TC2 Entry Read Address (High 16-bits)	Value range = 0 to 3 (max) Max value is 3: Combined: 0x03FFFF = 262143 entries
40104	104	103	Temperature log TC3 Entry Read Address (Low 16-bits)	Temp log entry number to start the next read cycle at. Max size is currently 512kB (256k entries = 262143 entries, 16-bit data) Temperature log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40105	105	104	Temperature log TC3 Entry Read Address (High 16-bits)	Value range = 0 to 3 (max) Max value is 3: Combined: 0x03FFFF = 262143 entries
40106	106	105	Reserved	
40107	107	106	Temperature log TC1 Read back trigger	Reading from this address triggers a readout of the TC1 Temp log starting at the Entry Read Address (addr 99 & 100), for the requested number of entries.
40108	108	107	Temperature log TC2 Read back trigger	Reading from this address triggers a readout of the TC2 Temp log starting at the Entry Read Address (addr 101 & 102), for the requested number of entries.
40109	109	108	Temperature log TC3 Read back trigger	Reading from this address triggers a readout of the TC3 Temp log starting at the Entry Read Address (addr 103 & 104), for the requested number of entries.
40110	110	109	Shutdown log: Total Count (Upper 16-bits)	Holds the number of shutdown entries stored currently in the log. Max size is currently 65535 entries (time and date stamped). V00.02.29+: Value range = 0 here due to max SD log size of 65535 entries total (0x0000FFFF = 65535)

40111	111	110	Shutdown log Entry Read Address (Low 16-bits)	SD log entry number to start the next read cycle at. Max log size is 512kB (kbytes) for SD log: 65535 eight-byte SD log entries. Shutdown log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40112	112	111	Shutdown log Entry Read Address (High 16-bits)	Value range = 0 (V00.02.29+) Combined: 0x0000FFFF = 65535 entries (accessing an address outside the area containing valid data in the shutdown log will return two bytes of 0x00 0x00)
40113	113	112	Reserved	
40114	114	113	Shutdown log Read back trigger	Issue a read to trigger a readout of the SD log starting at the Entry Read Address, for the requested number of bytes (in the modbus request message)
				Values are read back as 16-bit values due to the nature of Modbus registers: MSB 0 (byte 0), LSB 0 (byte 1), MSB 1 (byte 2), LSB 1 (byte 3), MSB 2 (byte 4), LSB 2 (byte 5), MSB 3 (byte 6), LSB 3 (byte 7)
				If there's more values in the log, the Master must adjust the starting Address to read from and issue another read command with the number of values to read in the Modbus packet.
				Byte 0: Year (0 - 99)
				Byte 1: Month (1 - 12)
				Byte 2: Day (1 - 31)
				Byte 3: Hours (0 - 23) (24-hour time)
				Byte 4: Minutes (0 - 59)
				Byte 5: Shutdown log byte - Byte 1
				Byte 6: Shutdown log byte - Byte 2
				Byte 7: Shutdown log byte - Byte 3
			Shutdown log bytes (byte 5,6, & 7) organization:	Bit 7..0 (7 6 5 4 3 2 1 0)
			"Byte 1" of SD Log register (Byte 5):	Bit 0: AUX2 power rung
				Bit 1: AUX1 power rung
				Bit 2: Level power rung
				Bit 3: Low Gas power rung
				Bit 4: IGN 2 Flame Fails
				Bit 5: TC3 High-Temp Shutdown
				Bit 6: 4-20mA Level Input
				Bit 7: 4-20mA Pressure Input
			"Byte 2" of SD Log register (Byte 6):	Bit 0: High-Temp Shutdown (TC2)

				Bit 1: High Gas Shutdown power rung
				Bit 2: Remote Stop/Start power rung
				Bit 3: Modbus Remote Stop
				Bit 4: Power Fail
				Bit 5: On/Off Switch (Stop button)
				Bit 6: IGN 1 Flame Fails
				Bit 7: Dual TC1/2 Difference SD
			"Byte 3" of SD Log register (Byte 7):	Bit 0: Low Temp Shutdown
				Bit 1: Reserved
				Bit 2: Reserved
				Bit 3: Reserved
				Bit 4: Reserved
				Bit 5: Reserved
				Bit 6: Reserved
				Bit 7: Reserved
40115	115	114	4-20mA Output 1 Low Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40116	116	115	4-20mA Output 1 High Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40117	117	116	4-20mA Output 1 Full Scale Ramp Rate	5s - 120s (Time for output to rise from 4 to 20mA or to decrease from 20 to 4mA across the entire scale.)
40118	118	117	4-20mA Output 1 Proportional Valve Minimum Enable	0 = 4-20mA output soft start is disabled, 1 = 4-20mA output soft start is enabled when in shutdown
40119	119	118	4-20mA Output 1 Proportional Valve Minimum mA Set value	400-2000 Soft start value for 4-20mA Output ie: 4-20mA setting to output when in shutdown (400 = 4.00mA, 2000 = 20.00mA)
40120	120	119	4-20mA Output 2 Low Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40121	121	120	4-20mA Output 2 High Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40122	122	121	4-20mA Output 2 Full Scale Ramp Rate	5s - 120s (Time for output to rise from 4 to 20mA or to decrease from 20 to 4mA across the entire scale.)
40123	123	122	4-20mA Output 2 Proportional Valve Minimum Enable	0 = 4-20mA output soft start is disabled, 1 = 4-20mA output soft start is enabled when in shutdown
40124	124	123	4-20mA Output 2 Proportional Valve Minimum mA Set value	400-2000 Soft start value for 4-20mA Output ie: 4-20mA setting to output when in shutdown (400 = 4.00mA, 2000 = 20.00mA)
40125	125	124	4-20mA Output 3 Select (0 - 7)	(see addresses 58 and 59 for Output 1) (if a third 4-20mA Output is available)
40126	126	125	4-20mA Output 3 Low Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40127	127	126	4-20mA Output 3 High Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40128	128	127	4-20mA Output 3 Full Scale Ramp Rate	5s - 120s (Time for output to rise from 4 to 20mA or to decrease from 20 to 4mA across the entire scale.)

40129	129	128	4-20mA Output 3 Proportional Valve Minimum Enable	0 = 4-20mA output soft start is disabled, 1 = 4-20mA output soft start is enabled when in shutdown
40130	130	129	4-20mA Output 3 Proportional Valve Minimum mA Set value	400-2000 Soft start value for 4-20mA Output ie: 4-20mA setting to output when in shutdown (400 = 4.00mA, 2000 = 20.00mA)
40131	131	130	IGN1 Enable/disable	0 - 1 (1 = Enable, 0 = disable)
40132	132	131	IGN2 Enable/disable	0 - 1 (1 = Enable, 0 = disable)
40133	133	132	Degrees C / Degrees F select	0 = degrees C, 1 = degrees F
40134	134	133	TC2 Enable/Disable	0 - 1 (1 = Enable, 0 = disable)
40135	135	134	TC3 Enable/Disable	0 - 1 (1 = Enable, 0 = disable)
40136	136	135	TC3 Aux HT SD	0 - 1 (1 = Yes, 0 = No) 1 = use TC3 as HT SD, 0 = do not use TC3 as HT SD (default)
40137	137	136	Intermittent / Continuous Pilot Select	0 = Intermittent, 1 = Continuous
40138	138	137	Pilot to Mains Delay value	10s - 120s (100 - 1200 (in tenths of seconds))
40139	139	138	Number of Ignition Trials	1 - 3
40140	140	139	All Ignitors shutdown if Flame Fail on one	0 = No, 1 = Yes
40141	141	140	AUX1 Relay Control	0 = TC1 Setpoint
				1 = TC1 IGN2 Setpoint
				2 = TC2 Setpoint
				3 = TC3 Setpoint
				4 = TC1 Custom Setpoint
				5 = TC2 Custom Setpoint
				6 = TC3 Custom Setpoint
				7 = IGN1 FF Alarm (on when IGN1 is in FF)
				8 = IGN2 FF Alarm (on when IGN2 is in FF)
				9 = Modbus Control (turns Off upon any SD)
				10 = TMain1 Mirror
				11 = TMain2 Mirror
40142	142	141	AUX1 Relay Custom Temperature Setpoint	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40143	143	142	AUX1 Relay Custom Temperature Deadband	1 - 5 degC, 2 - 10 degF
40144	144	143	Reserved	
40145	145	144	AUX2 Relay Control	0 - 11 (see AUX1 Relay Control above)
40146	146	145	AUX2 Relay Custom Temperature Setpoint	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40147	147	146	AUX2 Relay Custom Temperature Deadband	1 - 5 degC, 2 - 10 degF
40148	148	147	Reserved	
40149	149	148	TC1 temp setpoint (deg C), IGN2 (if firmware enabled for	Writing a value to TC1, IGN2 (if firmware enabled for separate IGN1/2 setpoints) in

			separate IGN1/2 setpoints for TC1)	degrees C, also writes to the TC1 degrees F register (after conversion)
40150	150	149	TC1 temp setpoint (deg F) , IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	Writing a value to TC1, IGN2 (if firmware enabled for separate IGN1/2 setpoints) in degrees F, also writes to the TC1 degrees C register (after conversion)
40151	151	150	Deadband setting, TC1, IGN2	1 - 5 degC, 2 - 10 degF (if firmware enabled for separate IGN1/2 setpoints for TC1)
40152	152	151	Purge Cycle On/Off Select	0 = Off, 1 = On
40153	153	152	Purge Cycle Time	0 - 300s (Time between pressing Start and Ignitor(s) starting)
40154	154	153	4-20mA Inter-Purge Time	0 - 120s (Extra Time delay between Purge and first ignition trial for sparking)
40155	155	154	Int-Purge Time	0 - 120s (Purge time between each IGN trial)
40156	156	155	Power Save	0 = disabled, 1 = turn off display after 10 minutes. Press any button to turn on again
40157	157	156	Alarm if Any IGN FF / Alarm only if both IGN are in FF	0 = (normal) trip alarm/status contacts if Any of the two burners go into FF, 1 = only trip Alarm/status contacts if both burners go into FF (and only if both are enabled)
40158	158	157	TC1/2 Difference Shutdown Control	0 = normal operation, 1 = if TC1 and TC2 are different by 10 degrees C, issue a latching shutdown (using a dual thermocouple)
40159	159	158	4-20mA Output 1 Proportional Valve Ignitor Control Select	0 = both IGN1&2 controlled (default), 1 = IGN1 controlled, 2 = IGN2 controlled
40160	160	159	4-20mA Output 2 Proportional Valve Ignitor Control Select	0 = both IGN1&2 controlled (default), 1 = IGN1 controlled, 2 = IGN2 controlled
40161	161	160	4-20mA Output 3 Proportional Valve Ignitor Control Select	0 = both IGN1&2 controlled (default), 1 = IGN1 controlled, 2 = IGN2 controlled
40162	162	161	Reserved	
40163	163	162	Reserved	
40164	164	163	Reserved	
40165	165	164	Reserved	
40166	166	165	Reserved	
40167	167	166	Reserved	
40168	168	167	Reserved	
40169	169	168	Reserved	
40170	170	169	Reserved	
40171	171	170	Reserved	
40172	172	171	Shutdown Log: Mask Register 2	Second register for SD log mask (ie: enabling which shutdowns to log in the SD log)
				Bit 0: Low Temp SD
				Bit 1: Reserved
				Bit 2: Reserved
				Bit 3:
				Bit 4:

				Bit 5:
				Bit 6:
				Bit 7:
40173	173	172	Low Temperature Shutdown Selection	Selects which Thermocouples to use as the low temp shutdown
				0 = No, Disabled
				1 = TC1, shutdown
				2 = TC2, shutdown
				3 = TC3, shutdown
				4 = TC1&2, shutdown
				5 = TC1&3, shutdown
				6 = TC2&3, shutdown
				7 = TC1&2&3, shutdown
				8 = TC1, alarm, no shutdown
				9 = TC2, alarm, no shutdown
				10 = TC3, alarm, no shutdown
				11 = TC1&2, alarm, no shutdown
				12 = TC1&3, alarm, no shutdown
				13 = TC2&3, alarm, no shutdown
				14 = TC1&2&3, alarm, no shutdown
40174	174	173	Shutdown Count - Low Temp Shutdowns	All shutdown counts are 16-bits (range is 0 to 65535). All Shutdown Count registers will increment regardless of whether they are stored in the Shutdown Log.
40175	175	174	Reserved	
40176	176	175	Reserved	
40177	177	176	Low Temperature Shutdown Setpoint (Deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
40178	178	177	Low Temperature Shutdown Setpoint (Deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
40179	179	178	Reserved	
40180	180	179	Reserved	
40181	181	180	Reserved	
40182	182	181	Reserved	
40183	183	182	Reserved	
40184	184	183	Reserved	
40185	185	184	Reserved	
40186	186	185	Reserved	
40187	187	186	Reserved	
40188	188	187	Reserved	
40189	189	188	Reserved	

40190	190	189	Reserved	
40191	191	190	Reserved	
40192	192	191	Reserved	
40193	193	192	Reserved	
40194	194	193	Reserved	

Notes:

- Read Holding registers function code 0x03 can read the internal register settings for the CSC400 and the Temperature and Shutdown logs.
- Some registers are used as "Write-only" registers (see function code 0x06, Write Single Holding Register, for descriptions of the write only registers)

Recommended Modbus Read Holding Registers request message sent to CSC400 (PDU, protocol data unit):

0x03 0x00 0x0D 0x00 0x01

Function - Read Holding Registers	0x03	
Starting Address Hi	0x00	
Starting Address Lo	0x0D	0x0D = 13 : Temperature log: Total Count
Number of Registers Hi	0x00	
Number of Registers Lo	0x01	

Modbus Read Holding Registers response message sent back to Master from CSC400 (PDU, protocol data unit):

0x03 0x02 0x00 0x37

Function - Read Input Registers	0x03	
Byte Count	0x02	
Register Value Hi Byte	0x00	Value = 0x0037 = 55 values available for reading in each Temperature log (TC1 and TC2)
Register Value Lo Byte	0x37	

Function Code 0x04 - Read Input Registers

Input registers are 16-bit values (2 bytes)
Register bytes are read back as MSB then LSB

SCADA Pack Register Address	Register #	Modbus Inputs Register Address	Description	Notes
30001	1	0	TC1 current temp (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
30002	2	1	TC2 current temp (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
30003	3	2	TC1 current temp (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
30004	4	3	TC2 current temp (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
30005	5	4	TC3 current temp (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
30006	6	5	TC3 current temp (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
30007	7	6	Reserved	
30008	8	7	Reserved	
30009	9	8	4-20mA Input 1 (Level) value	400 - 2000 (ie: 4.00 - 20.00mA). Dependant on units selected: "247" = 24.7% if percent is selected
30010	10	9	4-20mA Input 2 (Pressure)	400 - 2000 (ie: 4.00 - 20.00mA)

			value	

Notes:

- Read input registers function code 0x04 can read the temperature of both thermocouples in either degrees C or F.

Recommended Modbus Read Input Registers request message sent to CSC400 (PDU, protocol data unit):

0x04 0x00 0x02 0x00 0x01

Function - Read Input Registers	0x04
Starting Address Hi	0x00
Starting Address Lo	0x02
Quantity of Outputs Hi	0x00
Quantity of Outputs Lo	0x01

Modbus Read Input Registers response message sent back to Master from CSC400 (PDU, protocol data unit):

0x04 0x02 0xYY 0xXX

Function - Read Input Registers	0x04	
Byte Count	0x02	
Input Reg. 3 Hi Byte	0xYY	Input register #3, Hi byte
Input Reg. 3 Lo Byte	0xXX	Input register #3, Lo byte

Function Code 0x05 – Write Single "Coil" (or Setting)

The individual coils can't actually be written to, they're influenced by the temperature.
Remote Stop and Remote Start are allowed though.
Remote Stop will turn off all relays in the CSC400. CSC400 can only be started again by a Remote Start command, or by turning ON/OFF switch to OFF, then back to ON.

SCADAPack Register Address	Coil #	Modbus Write Coil Address	Description	Notes
1	1	0	AUX1 Control Relay	Write access only allowed when the Modbus control option is selected in the AUX1 Relay Settings (Holding Register 140)
2	2	1	AUX2 Control Relay	Write access only allowed when the Modbus control option is selected in the AUX1 Relay Settings (Holding Register 144)
	3 - 16	2 - 15	(No direct write access to relays)	
17	17	16	Increment TC1 setpoint	ON = increment TC1 setpoint, OFF = no effect
18	18	17	Decrement TC1 setpoint	ON = increment TC1 setpoint, OFF = no effect
19	19	18	Increment TC2 setpoint	ON = increment TC2 setpoint, OFF = no effect
20	20	19	Decrement TC2 setpoint	ON = increment TC2 setpoint, OFF = no effect
21	21	20	Increment TC3 setpoint	ON = increment TC3 setpoint, OFF = no effect
22	22	21	Decrement TC3 setpoint	ON = increment TC3 setpoint, OFF = no effect
23	23	22	Remote Stop	ON = Stop, OFF = no effect
24	24	23	Remote Start	ON = Start, OFF = no effect
25	25	24	Increment TC1, IGN2	ON = increment TC1, IGN2 setpoint, OFF =

			setpoint (if firmware enabled for separate IGN1/2 setpoints)	no effect
26	26	25	Decrement TC1, IGN2 setpoint (if firmware enabled for separate IGN1/2 setpoints)	ON = decrement TC1, IGN2 setpoint, OFF = no effect

Notes:

- Write Single "Coil" (or setting) function code 0x05 can increment/decrement the setpoint temperatures of either thermocouple, and can also trigger a Remote Stop or Remote Start command.
- "0xFF00" (or 65280 in decimal) turns a "coil" ON, "0x0000" turns a coil "OFF"
- For our "coils" or settings, 0x0000 or OFF, has no effect on the Setpoints or Remote Stop/Start settings.
- Remote Stop disables all power going to ignition module and closes all three valve solenoids
- Remote Stop can be cleared by a physical toggling of the ON/OFF switch or the Remote Reset power rung
- Remote Stop can also be cleared by receiving a Modbus message turning Remote Start ON

- Remote Start enables the CSC400 to be turned on
- Remote Start can be interrupted if ON/OFF switch is OFF, if Remote Reset is open, or if Shutdown is open, or if POC is still open
- Remote Start can also be cleared by receiving a Modbus message turning Remote Stop ON

Recommended Modbus Single "Coil" (or setting) request message sent to CSC400 (PDU, protocol data unit):

0x05 0x00 0x13 0xFF 0x00

Function - Write "Coil" (or setting)	0x05	
"Coil" or setting Address Hi	0x00	
"Coil" or setting Address Lo	0x13	This example (0x13 = 19) command decrements the TC2 setpoint by one degree for each command sent to the device from the master
"Coil" or setting Value Hi	0xFF	
"Coil" or setting Value Lo	0x00	

Modbus Single "Coil" (or setting) response message sent back to Master from CSC400 (PDU, protocol data unit):

0x05 0x00 0x13 0xFF 0x00

Function - Write "Coil" (or setting)	0x05
"Coil" or setting Address Hi	0x00
"Coil" or setting Address Lo	0x13
"Coil" or setting Value Hi	0xFF
"Coil" or setting Value Lo	0x00

Function Code 0x06 - Write Holding Registers

Holding registers are 16-bit values (2 bytes)
Register bytes are written as MSB then LSB

SCADA Pack Register Address	Register #	Modbus Holding Register Address	Description	Notes
40001	1	0	TC1 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064 Writing a value to TC1 in degrees C, also writes to the TC1 degrees F register (after conversion)
40002	2	1	TC2 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064 Writing a value to TC2 in degrees C, also writes to the TC2 degrees F register (after conversion)
40003	3	2	TC1 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4 Writing a value to TC1 in degrees F, also writes to the TC1 degrees C register (after conversion)
40004	4	3	TC2 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4 Writing a value to TC2 in degrees F, also writes to the TC2 degrees C register (after conversion)
40005	5	4	Reserved	
40006	6	5	Reserved	
40007	7	6	Reserved	
40008	8	7	Reserved	
40009	9	8	Reset serial communication settings to default (9600, 8N1)	"0xFFFF" resets serial communication settings to default after the response is sent back to the Master, all other values have no effect
				- Resets serial communication settings to 9600 baud and 8N1 format
40010	10	9	Temperature log: Enable/Disable	"0x00" = disable Temp logging
				"0x01" = enable Temp logging but only when not in shutdown (OFF, HT, SD, RR, Remote Stop, POC) (Default)
				"0x11" (17) = enable Temp logging, even when in shutdown (OFF, HT, SD, RR, Remote Stop, POC)
40011	11	10	Reserved	
40012	12	11	Temperature log: Record Rate setting	Value of "0" = save Temp every 5 minutes
				Value of "1" = save Temp every 10 minutes
				Value of "2" = save Temp every 15 minutes
				Value of "3" = save Temp every 20 minutes
				Value of "4" = save Temp every 30 minutes
				Value of "5" = save Temp every 60 minutes (default)
				Value of "6" = save Temp every 120 minutes

				Value of "7" = save Temp every 3 hours
				Value of "8" = save Temp every 4 hours
				Value of "9" = save Temp every 6 hours
				Values of "10" and above are reserved for debugging and future updates and may change: 10 = 5 sec, 11 = 10 sec, 12 = 15 sec, 13 = 20 sec, 14 = 30 sec, 17 = 1 sec, 18 = 3 sec
				Value of "15" = save Temp every 1 min
				Value of "16" = save Temp every 2 min
40013	13	12	Temperature log: Reset log	Writing a "0xFFFF" here resets (zeros) the Temp log, all other values have no effect
40014	14	13	Temperature log: Total Count (Lower 16-bits) (no write access)	Holds the number of temperature measurements currently in each log (TC1 and TC2). Max size is currently 512kB (256k entries, 16-bit data).
40015	15	14	Temperature log: Temperature Format	Value of "0" = store temp in currently selected format (eg: deg C if deg C selected by degC/degF DIP switch)
				Value of "1" = save Temp in degrees Celsius
				Value of "2" = save Temp in degrees Fahrenheit
40016	16	15	Reserved	
40017	17	16	Shutdown log: Clear/Reset	Writing a "0xFFFF" here resets (zeros) the Shutdown log, all other values have no effect
40018	18	17	Shutdown log: Total Count (Lower 16-bits) (no write access)	Holds the number of shutdowns detected stored currently in the log. Max size is currently 74898 entries (time and date stamped). Value range = 0 to 65535 (0 - 0xFFFF)
40019	19	18	Shutdown log: Mask register (Default value is 0xFFD3: all shutdowns are logged except for Stop/Reset button pushed, Remote Stop/Start, and Modbus Remote Stop)	Selects the type of shutdowns to store in the shutdown log. Uses both bytes of holding register. A "1" enables the selected shutdown to be stored in the Shutdown log. Eg: 0x13 (binary 0001 0011) only enables storing Power Fails, High Gas Shutdown power rung, and High-Temp shutdowns.
			(also see Mask register 2, holding register address 171)	A "1" in the selected bit position enables that type of shutdown to be recorded into the shutdown log.
				A "0" in the selected bit position means that that type of shutdown is NOT recorded in the shutdown log. It is still counted though in its corresponding count register
			Lower Byte	Bit 0: High-Temp Shutdown (TC2)
				Bit 1: High Gas Shutdown power rung
				Bit 2: Remote Start/Stop power rung
				Bit 3: Modbus remote stop
				Bit 4: Power Fails
				Bit 5: Stop Button
				Bit 6: IGN1 Flame Fails

				Bit 7: Dual TC1/2 difference SDs
			Upper Byte	Bit 0: AUX2 power rung
				Bit 1: AUX1 power rung
				Bit 2: Level power rung
				Bit 3: Low Gas power rung
				Bit 4: IGN2 Flame Fails
				Bit 5: TC3 High-Temp Shutdown
				Bit 6: 4-20mA Level Input SD
				Bit 7: 4-20mA Pressure Input SD
40020	20	19	Shutdown Count: TC1/2 Difference Shutdowns	SD: If TC1 & TC2 are different by more than 10°C, issue a latching shutdown
40021	21	20	Shutdown Count: IGN1 Flame Fails	All shutdown counts are 16-bits (range is 0 to 65535) and have no write access other than the "Shutdown Counts: Clear/Reset" register (modbus address 28)
40022	22	21	Shutdown Count: Stop Button	
40023	23	22	Shutdown Count: Power Fails	
40024	24	23	Shutdown Count: Modbus Remote Stops	
40025	25	24	Shutdown Count: Remote Stop/Start	
40026	26	25	Shutdown Count: High Gas Shutdown Power rung	
40027	27	26	Shutdown Count: High-Temp shutdowns (TC2)	
40028	28	27	Shutdown Count: Level Shutdown Power rung	
40029	29	28	Shutdown Counts: Clear/Reset	Clears/Zeros the shutdown counts in all shutdown count variables, and in EEPROM
				Writing a "0xFFFF" here resets (zeros) the Shutdown counters, all other values have no effect
40030	30	29	TMain IGN1 time on, days (no write access)	Indicates the number of total days the TMain IGN1 valve has been open/ON. Full result = days, hours, minutes
40031	31	30	TMain IGN1 time on, hours (no write access)	Indicates the number of hours the TMain IGN1 valve has been open/ON.
40032	32	31	TMain IGN1 time on, minutes (no write access)	Indicates the number of minutes the TMain IGN1 valve has been open/ON.
40033	33	32	TMain IGN1 time on, Clear/Reset	Clears/Zeros the TMain IGN1 ON time in all variables (days, hours, minutes) and in the EEPROM.
				Writing a "0xFFFF" here resets (zeros) the TMain ON timers, all other values have no effect.
40034	34	33	Analog reading of Main Input Voltage	Analog reading is in mV (approx.) 12VDC on input = 2V 24VDC on input = 4V 30VDC on input = 5V (may clamp at 4096mV)
40035	35	34	Reserved	

40036	36	35	CSC400 Mode	0 = PI mode , 1 = HE mode, 2 = FI mode (default)
40037	37	36	IGN1 ON Timer value (PI/HE mode) (no write access)	Ignitor 1 timer on value (in seconds) (PI/HE mode)
40038	38	37	IGN1 OFF Timer value (PI/HE mode) (no write access)	Ignitor 1 timer off value (in seconds) (PI/HE mode)
40039	39	38	CSC400 System State	0 = System is off, 1 = System is on
40040	40	39	Clock Set: Year	0 - 99 (valid values)
40041	41	40	Clock Set: Month	1 - 12
40042	42	41	Clock Set: Day	1 - 31
40043	43	42	Clock Set: Hour	0 - 23
40044	44	43	Clock Set: Minute	0 - 59
40045	45	44	Clock Set: Seconds	0 - 59
40046	46	45	TMain IGN2 time on, days (no write access)	Indicates the number of total days the TMain IGN2 valve has been open/ON. Full result = days, hours, minutes
40047	47	46	TMain IGN2 time on, hours (no write access)	Indicates the number of hours the TMain IGN2 valve has been open/ON.
40048	48	47	TMain IGN2 time on, minutes (no write access)	Indicates the number of minutes the TMain IGN2 valve has been open/ON.
40049	49	48	TMain IGN2 time on, Clear/Reset	Clears/Zeros the TMain IGN2 ON time in all variables (days, hours, minutes), and in the EEPROM.
40050	50	49	TC3 temp setpoint (deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064 Writing a value to TC3 in degrees C, also writes to the TC3 degrees F register (after conversion)
40051	51	50	TC3 temp setpoint (deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4 Writing a value to TC3 in degrees F, also writes to the TC3 degrees C register (after conversion)
40052	52	51	Shutdown Count: AUX 1 Shutdown Power rung (no write access)	All shutdown counts are 16-bits (range is 0 to 65535). All Shutdown Count registers will increment regardless of whether they are stored in the Shutdown Log.
40053	53	52	Shutdown Count: AUX 2 Shutdown Power rung (no write access)	
40054	54	53	Shutdown Count: Low Gas Shutdown Power rung (no write access)	
40055	55	54	Shutdown Count: TC3 High-Temp Shutdowns (no write access)	
40056	56	55	Shutdown Count: IGN2 Flame Fails (no write access)	
40057	57	56	Shutdown Count: 4-20 Level Input (no write access)	
40058	58	57	Shutdown Count: 4-20 Pressure Input (no write access)	

40059	59	58	4-20mA Output 1 Select (0 - 7)	0 = output temp TC1
				1 = output temp TC2
				2 = output temp TC3
				3 = output Proportional valve using TC1 (4-20mA slow ramp transition with 10 degree band (+/- 5 degrees) around the selected setpoint temp)
				4 = output Proportional valve using TC2
				5 = output Proportional valve using TC3
				6 = Level In (4-20 In 1) retransmit (repeater/splitter mode)
				7 = Pressure In (4-20 In 2) retransmit (repeater/splitter mode)
40060	60	59	4-20mA Output 2 Select (0 - 7)	(see 4-20mA Output 1 Select above)
40061	61	60	Deadband setting, TC1 (TC1 IGN1 if firmware enabled for separate IGN1/2 setpoints for TC1)	1 - 5 degC, 2 - 10 degF
40062	62	61	Deadband setting, TC2	1 - 5 degC, 2 - 10 degF
40063	63	62	Deadband setting, TC3	1 - 5 degC, 2 - 10 degF
40064	64	63	Shutdown Latch mask register	Selects the Shutdowns to use as latched shutdowns ie: selected shutdowns set to "1" cause the system to latch out. The Stop/Start button or a Modbus Remote Start command are needed to restart the system
			Lower byte of Holding Register	Bit 0: High-Temp Latch (TC2)
				Bit 1: High Gas Shutdown Latch
				Bit 2: Reserved
				Bit 3: Low Gas Shutdown Latch
				Bit 4: Power Fail Latch
				Bit 5: Level Shutdown Latch
				Bit 6: AUX1 Shutdown Latch
				Bit 7: AUX2 Shutdown Latch
			Upper Byte	Bit 0: 4-20 Input Level SD Latch
				Bit 1: 4-20 Input Pressure SD Latch
				Bit 2: TC3 High-Temp Latch
				Bit 3 - 7: Reserved
40065	65	64	IGN2 ON Timer value (PI mode) (no write access)	Ignitor 2 timer on value (in seconds). (PI mode)
40066	66	65	IGN2 OFF Timer value (PI mode) (no write access)	Ignitor 2 timer off value (in seconds). (PI mode)
40067	67	66	4-20mA Input 1 Format Select	0 = 4-20mA input, 1 = 1-5V input
40068	68	67	4-20mA Input 1 Lo Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input below Low trip point
40069	69	68	4-20mA Input 1 Hi Alarm	0 = disabled, 1 = enable alarm upon 4-20mA

			Select	input above High trip point
40070	70	69	4-20mA Input 1 SD on Low Alarm	0 = disabled, 1 = enable shutdown upon Lo Alarm
40071	71	70	4-20mA Input 1 SD on High Alarm	0 = disabled, 1 = enable shutdown upon Hi Alarm
40072	72	71	4-20mA Input 1 Custom Range Low Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40073	73	72	4-20mA Input 1 Custom Range High Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40074	74	73	4-20mA Input 1 Normal/Custom Range Low Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40075	75	74	4-20mA Input 1 Normal/Custom Range High Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40076	76	75	4-20mA Input 1 Custom Range Units	0 = mA (milliamps)
				1 = Volts
				2 = gallons
				3 = m3 (cubic meters)
				4 = psi
				5 = kPa
				6 = %
40077	77	76	4-20mA Input 1 Reserved	(no write access)
40078	78	77	4-20mA Input 1 Deadband	0 - 20 (no units, lowest increment), eg. 20 = 0.20mA or 0.020V
40079	79	78	4-20mA Input 1 Reserved	(no write access)
40080	80	79	4-20mA Input 1 Reserved	(no write access)
40081	81	80	4-20mA Input 1 Reserved	(no write access)
40082	82	81	4-20mA Input 1 Reserved	(no write access)
40083	83	82	4-20mA Input 2 Format Select	0 = 4-20mA input, 1 = 1-5V input
40084	84	83	4-20mA Input 2 Lo Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input below Low trip point
40085	85	84	4-20mA Input 2 Hi Alarm Select	0 = disabled, 1 = enable alarm upon 4-20mA input above High trip point
40086	86	85	4-20mA Input 2 SD on Low Alarm	0 = disabled, 1 = enable shutdown upon Lo Alarm
40087	87	86	4-20mA Input 2 SD on High Alarm	0 = disabled, 1 = enable shutdown upon Hi Alarm
40088	88	87	4-20mA Input 2 Custom Range Low Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40089	89	88	4-20mA Input 2 Custom Range High Value	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40090	90	89	4-20mA Input 2 Normal/Custom Range Low Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40091	91	90	4-20mA Input 2 Normal/Custom Range High Trippoint	0 - 65535, "400" = 4.00mA, "2000" = 20.00mA
40092	92	91	4-20mA Input 2 Custom Range Units	(see "4-20mA Input 1 Custom Range Units" section above)

40093	93	92	4-20mA Input 2 Reserved	(no write access)
40094	94	93	4-20mA Input 2 Deadband	0 - 20 (no units, lowest increment), eg. 20 = 0.20mA or 0.020V
40095	95	94	4-20mA Input 2 Reserved	(no write access)
40096	96	95	4-20mA Input 2 Reserved	(no write access)
40097	97	96	4-20mA Input 2 Reserved	(no write access)
40098	98	97	4-20mA Input 2 Reserved	(no write access)
40099	99	98	Temperature log: Total Count (Upper 16-bits) (all 3 Temp logs are saved simultaneously) (no write access)	Holds the upper 16-bits of the number of temperature measurements currently in each log (TC1, TC2, TC3). Max size is currently 512kB (256k entries, 16-bit data) Value range = 0 to 3 (max)
40100	100	99	Temperature log TC1 Entry Read Address (Low 16-bits)	Temp log entry number to start the next read cycle at. Max size is currently 512kB (256k entries = 262143 entries, 16-bit data) Temperature log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40101	101	100	Temperature log TC1 Entry Read Address (High 16-bits)	Value range = 0 to 3 (max) Max value is 3: Combined: 0x03FFFF = 262143 entries
40102	102	101	Temperature log TC2 Entry Read Address (Low 16-bits)	Temp log entry number to start the next read cycle at. Max size is currently 512kB (256k entries = 262143 entries, 16-bit data) Temperature log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40103	103	102	Temperature log TC2 Entry Read Address (High 16-bits)	Value range = 0 to 3 (max) Max value is 3: Combined: 0x03FFFF = 262143 entries
40104	104	103	Temperature log TC3 Entry Read Address (Low 16-bits)	Temp log entry number to start the next read cycle at. Max size is currently 512kB (256k entries = 262143 entries, 16-bit data) Temperature log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40105	105	104	Temperature log TC3 Entry Read Address (High 16-bits)	Value range = 0 to 3 (max) Max value is 3: Combined: 0x03FFFF = 262143 entries
40106	106	105	Reserved	(no write access)
40107	107	106	Temperature log TC1 Read back trigger	Reading from this address triggers a readout of the TC1 Temp log starting at the Entry Read Address (addr 99 & 100), for the requested number of entries.
40108	108	107	Temperature log TC2 Read back trigger	Reading from this address triggers a readout of the TC2 Temp log starting at the Entry Read Address (addr 101 & 102), for the requested number of entries.
40109	109	108	Temperature log TC3 Read back trigger	Reading from this address triggers a readout of the TC3 Temp log starting at the Entry Read Address (addr 103 & 104), for the requested number of entries.
40110	110	109	Shutdown log: Total Count (Upper 16-bits) (no write access)	Holds the number of shutdown entries stored currently in the log. Max size is currently 65535 entries (time and date stamped).

				V00.02.29+: Value range = 0 here due to max SD log size of 65535 entries total (0x0000FFFF = 65535)
40111	111	110	Shutdown log Entry Read Address (Low 16-bits)	SD log entry number to start the next read cycle at. Max log size is 512kB (kbytes) for SD log: 65535 eight-byte SD log entries. Shutdown log contents and settings are saved if a power failure occurs. Value range = 0 to 65535 (0 - 0xFFFF)
40112	112	111	Shutdown log Entry Read Address (High 16-bits)	Value range = 0 (V00.02.29+) Combined: 0x0000FFFF = 65535 entries (accessing an address outside the area containing valid data in the shutdown log will return two bytes of 0x00 0x00)
40113	113	112	Reserved	(no write access)
40114	114	113	Shutdown log Read back trigger (no write access)	(see Shutdown log Read back trigger register in Function Code 0x03 - Read Holding Registers for more details)
40115	115	114	4-20mA Output 1 Low Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40116	116	115	4-20mA Output 1 High Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40117	117	116	4-20mA Output 1 Full Scale Ramp Rate	5s - 120s (Time for output to rise from 4 to 20mA or to decrease from 20 to 4mA across the entire scale.)
40118	118	117	4-20mA Output 1 Proportional Valve Minimum Enable	0 = 4-20mA output soft start is disabled, 1 = 4-20mA output soft start is enabled when in shutdown
40119	119	118	4-20mA Output 1 Proportional Valve Minimum mA Set value	400-2000 Soft start value for 4-20mA Output ie: 4-20mA setting to output when in shutdown (400 = 4.00mA, 2000 = 20.00mA)
40120	120	119	4-20mA Output 2 Low Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40121	121	120	4-20mA Output 2 High Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40122	122	121	4-20mA Output 2 Full Scale Ramp Rate	5s - 120s (Time for output to rise from 4 to 20mA or to decrease from 20 to 4mA across the entire scale.)
40123	123	122	4-20mA Output 2 Proportional Valve Minimum Enable	0 = 4-20mA output soft start is disabled, 1 = 4-20mA output soft start is enabled when in shutdown
40124	124	123	4-20mA Output 2 Proportional Valve Minimum mA Set value	400-2000 Soft start value for 4-20mA Output ie: 4-20mA setting to output when in shutdown (400 = 4.00mA, 2000 = 20.00mA)
40125	125	124	4-20mA Output 3 Select (0 - 7)	(see addresses 58 and 59 for Output 1) (if a third 4-20mA Output is available)
40126	126	125	4-20mA Output 3 Low Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40127	127	126	4-20mA Output 3 High Temp Value	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40128	128	127	4-20mA Output 3 Full Scale Ramp Rate	5s - 120s (Time for output to rise from 4 to 20mA or to decrease from 20 to 4mA across the entire scale.)
40129	129	128	4-20mA Output 3 Proportional Valve Minimum Enable	0 = 4-20mA output soft start is disabled, 1 = 4-20mA output soft start is enabled when in shutdown

40130	130	129	4-20mA Output 3 Proportional Valve Minimum mA Set value	400-2000 Soft start value for 4-20mA Output ie: 4-20mA setting to output when in shutdown (400 = 4.00mA, 2000 = 20.00mA)
40131	131	130	IGN1 Enable/disable	0 - 1 (1 = Enable, 0 = disable)
40132	132	131	IGN2 Enable/disable	0 - 1 (1 = Enable, 0 = disable)
40133	133	132	Degrees C / Degrees F select	0 = degrees C, 1 = degrees F
40134	134	133	TC2 Enable/Disable	0 - 1 (1 = Enable, 0 = disable)
40135	135	134	TC3 Enable/Disable	0 - 1 (1 = Enable, 0 = disable)
40136	136	135	TC3 Aux HT SD	0 - 1 (1 = Yes, 0 = No) 1 = use TC3 as HT SD, 0 = do not use TC3 as HT SD (default)
40137	137	136	Intermittent / Continuous Pilot Select	0 = Intermittent, 1 = Continuous
40138	138	137	Pilot to Mains Delay value	10s - 120s (100 - 1200 (in tenths of seconds))
40139	139	138	Number of Ignition Trials	1 - 3
40140	140	139	All Ignitors shutdown if Flame Fail on one	0 = No, 1 = Yes
40141	141	140	AUX1 Relay Control	0 = TC1 IGN1 Setpoint
				1 = TC1 IGN2 Setpoint
				2 = TC2 Setpoint
				3 = TC3 Setpoint
				4 = TC1 Custom Setpoint
				5 = TC2 Custom Setpoint
				6 = TC3 Custom Setpoint
				7 = IGN1 FF Alarm (on when IGN1 is in FF)
				8 = IGN2 FF Alarm (on when IGN2 is in FF)
				9 = Modbus Control (turns Off upon any SD)
				10 = TMain1 Mirror
				11 = TMain2 Mirror
40142	142	141	AUX1 Relay Custom Temperature Setpoint	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40143	143	142	AUX1 Relay Custom Temperature Deadband	1 - 5 degC, 2 - 10 degF
40144	144	143	Reserved	
40145	145	144	AUX2 Relay Control	0 - 11 (see AUX1 Relay Control above)
40146	146	145	AUX2 Relay Custom Temperature Setpoint	Signed value: -600 to 12000 (in tenths of deg C) or -760 to 21920 (in tenths of deg F)
40147	147	146	AUX2 Relay Custom Temperature Deadband	1 - 5 degC, 2 - 10 degF
40148	148	147	Reserved	
40149	149	148	TC1 temp setpoint (deg C), IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	Writing a value to TC1, IGN2 (if firmware enabled for separate IGN1/2 setpoints) in degrees C, also writes to the TC1 degrees F register (after conversion)
40150	150	149	TC1 temp setpoint (deg F) ,	Writing a value to TC1, IGN2 (if firmware

			IGN2 (if firmware enabled for separate IGN1/2 setpoints for TC1)	enabled for separate IGN1/2 setpoints) in degrees F, also writes to the TC1 degrees C register (after conversion)
40151	151	150	Deadband setting, TC1, IGN2	1 - 5 degC, 2 - 10 degF (if firmware enabled for separate IGN1/2 setpoints for TC1)
40152	152	151	Purge Cycle On/Off Select	0 = Off, 1 = On
40153	153	152	Purge Cycle Time	0 - 300s (Time between pressing Start and Ignitor(s) starting)
40154	154	153	4-20mA Inter-Purge Time	0 - 120s (Extra Time delay between Purge and ignitor sparking)
40155	155	154	Int-Purge Time	0 - 120s (Purge time between each IGN trial)
40156	156	155	Power Save	0 = disabled, 1 = turn off display after 10 minutes. Press any button to turn on again
40157	157	156	Alarm if Any IGN FF / Alarm only if both IGN are in FF	0 = (normal) trip alarm/status contacts if Any of the two burners go into FF, 1 = only trip Alarm/status contacts if both burners go into FF (and only if both are enabled)
40158	158	157	TC1/2 Difference Shutdown Control	0 = normal operation, 1 = if TC1 and TC2 are different by 10 degrees C, issue a latching shutdown (using a dual thermocouple)
40159	159	158	4-20mA Output 1 Proportional Valve Ignitor Control Select	0 = both IGN1&2 controlled (default), 1 = IGN1 controlled, 2 = IGN2 controlled
40160	160	159	4-20mA Output 2 Proportional Valve Ignitor Control Select	0 = both IGN1&2 controlled (default), 1 = IGN1 controlled, 2 = IGN2 controlled
40161	161	160	4-20mA Output 3 Proportional Valve Ignitor Control Select	0 = both IGN1&2 controlled (default), 1 = IGN1 controlled, 2 = IGN2 controlled
40162	162	161	Reserved	
40163	163	162	Reserved	
40164	164	163	Reserved	
40165	165	164	Reserved	
40166	166	165	Reserved	
40167	167	166	Reserved	
40168	168	167	Reserved	
40169	169	168	Reserved	
40170	170	169	Reserved	
40171	171	170	Reserved	
40172	172	171	Shutdown Log: Mask Register 2	Second register for SD log mask (ie: enabling which shutdowns to log in the SD log)
				Bit 0: Low Temp SD
				Bit 1: Reserved
				Bit 2: Reserved
				Bit 3:
				Bit 4:
				Bit 5:
				Bit 6:
				Bit 7:

40173	173	172	Low Temperature Shutdown Selection	Selects which Thermocouples to use as the low temp shutdown (see Low Temperature Shutdown Selection register in Function Code 0x03 - Read Holding Registers for more details)
40174	174	173	Shutdown Count - Low Temp Shutdowns	All shutdown counts are 16-bits (range is 0 to 65535). All Shutdown Count registers will increment regardless of whether they are stored in the Shutdown Log.
40175	175	174	Reserved	
40176	176	175	Reserved	
40177	177	176	Low Temperature Shutdown Setpoint (Deg C)	Signed value: -60 = 0xFFC4, 100 = 0x0064
40178	178	177	Low Temperature Shutdown Setpoint (Deg F)	Signed value: -76 = 0xFFB4, 212 = 0x00D4
40179	179	178	Reserved	
40180	180	179	Reserved	
40181	181	180	Reserved	
40182	182	181	Reserved	
40183	183	182	Reserved	
40184	184	183	Reserved	
40185	185	184	Reserved	
40186	186	185	Reserved	
40187	187	186	Reserved	
40188	188	187	Reserved	
40189	189	188	Reserved	
40190	190	189	Reserved	
40191	191	190	Reserved	
40192	192	191	Reserved	
40193	193	192	Reserved	
40194	194	193	Reserved	

Notes:

- Write Holding registers function code 0x06 can write the internal register settings for the CSC400 and the Temperature and Shutdown log settings.

Recommended Modbus Write Holding Registers request message sent to CSC400 (PDU, protocol data unit):

0x06 0x00 0x03 0x01 0xF4

Function - Write Holding Register	0x06	
Register Address Hi	0x00	
Register Address Lo	0x03	This example (register address 0x03) sets the setpoint of TC2 in degrees F to a value of 500 degrees F (0x01F4).
Register Value Hi	0x01	
Register Value Lo	0xF4	

Modbus Write Holding Register response message sent back to Master from CSC400 (PDU, protocol data unit):

0x06 0x00 0x03 0x01 0xF4

Function - Write Holding Register	0x06
Register Address Hi	0x00
Register Address Lo	0x03
Register Value Hi	0x01
Register Value Lo	0xF4

Function Code 0x08 - Diagnostics

Sub-Function Code		Function Name	Length (bits)	Description of Use With CSC400
(Dec)	(Hex)			
0	0x00	Return Query Data (loopback)		Echoes the request back to the Master
1	0x01	Restart Communications Option		Restart communications port and brings device out of Listen Only mode if currently in it
4	0x04	Force Listen Only Mode		Device will not respond to requests if put in this mode
10	0x0A	Clear Counters and Diagnostic Register		Clear Counters and Diagnostic Register
11	0x0B	Return Bus Message Count		Returns number of messages on the bus since last restart, clear counters operation, or powerup (even if not addressed to this device)
12	0x0C	Return Bus Communication Error Count		Returns number of CRC errors since last restart, clear counters operation, or powerup
13	0x0D	Return Bus Exception Error Count		Returns number of exception responses sent back to the Master since last restart, clear counters operation, or powerup
14	0x0E	Return Slave Message Count		Returns number of messages addressed to this device since last restart, clear counters operation, or powerup
		Get Communication Event Counter		Used to get a status word and an event count from the communication event counter
		Get Communication Event Log		Used to get a status word, event count, message count, and a field of event bytes from the CSC400. The status word and event counts are identical to that returned by the Get Communications Event Counter function (11, 0B hex).
		Report Slave ID		Used to read the Slave ID, the description of the type, the current status, and other information specific to the CSC400.
14	0x0E	Read Device Identification		Allows reading the identification and additional information relative to the physical and functional description of the CSC400

Function Code 43 / 14 (0x2B / 0x0E) - Read Device Identification

This function code allows reading the identification and additional information relative to the physical and functional description of a remote device.

Appendix B - CSC400 Rev 2A Modbus Technical Specifications

Notes:

- Receivers are designed to fail-safe to a logic high output state if inputs (terminals A and B) are left un-driven or shorted. If the bus is un-driven for long periods of time, the receivers are designed to not require line polarization on the bus (adding a pullup resistor to "A" and a pulldown resistor to "B"). Line polarization may be enabled (via the two DIP switches in the Modbus section on the top of the CSC400 Controller) for use with other devices on the same RS-485 bus.
- Drivers are protected from excess current flow caused by bus contention or output short-circuits by both an internal current limit and a thermal-overload shutdown.
- RS-485 inputs (terminals A and B) are protected against ESD events up to +/- 15kV (Air-Gap and Human Body Model) and up to +/- 8kV Contact Discharge (IEC61000-4-2).
- All components on the CSC400 Controller are RoHS compliant.

Specification	Default Value	Possible Values
Modbus Protocol	Modbus RTU	Modbus RTU
Modbus Slave ID (address)	2	1 - 247
Modbus/RS-485 Serial Settings:		
Baud rate	9600	300, 1200, 2400, 4800, 9600, 19200, 38400
Number of data bits	8	8
Parity bit setting	None	None, Even, Odd
Stop bits	1	1, 2 (only with parity set to "None")
Operating Temperature		-40°C to 60°C
RS-485 Signals:		
Input voltage on A and B signals		-7 VDC to +12 VDC
Driver Short Circuit Current Limit		+/- 250mA maximum
Differential Driver Output, No Load		5 VDC
Differential Driver Output, R_L = 54ohms		1.5 VDC minimum 2.7 VDC typical 5 VDC maximum
Receiver Input Resistance		96kohm minimum ($1/8^{th}$ of a Modbus "Unit Load")
Receiver Differential Threshold (VA – VB)		-200mV minimum -125mV typical -40mV maximum
Receiver Input Hysteresis		25mV typical
Termination		None or 120ohms (2-pin jumper may be installed by user)
Line Polarization Resistors		560 ohms +/- 1%, selectable by user via two DIP switches
Line Polarization Pullup voltage		5 VDC +/- 1% (5% max)
Line Polarization Pulldown voltage		RS-485 Isolated or Common GND (0V)
Physical Dimensions:		

Length		6.750” (171.45mm)
Width		4.850” (123.19mm)
Height, maximum (from bottom of components on bottom layer to top of components on top layer)		1.130” (28.70mm)

Appendix C - Modbus/RS-485 Cabling Technical Details

Refer to the Modbus documentation available at www.modbus.org:

RS-485 Signal Naming Conventions

The RS485 signal naming convention used in this document and by many RS485 transceiver vendors is reversed from what the EIA/TIA-485 specification states:

CSC400 Modbus/RS485 Documentation	EIA/TIA-485 Naming Convention	Modbus Specification Name	Description
A ("Data A +")	B	D1	Non-Inverting, Transceiver Terminal 1, V1 voltage (V1 > V0 for binary 1 (OFF) state
B ("Data B –")	A	D0	Inverting, Transceiver Terminal 0, V0 voltage (V0 > V1 for binary 0 (ON) state
Isolated GND (or common GND)	C	Common	Signal and Optional Power Supply common ground

Half-Duplex vs Full-Duplex

Half-duplex communication allows only one device to communicate over the 2 RS-485 wires (one differential pair). Full-duplex communication adds another pair of wires to allow bi-directional communication to occur simultaneously.

For the Modbus protocol, the Master pair would be used by the master to communicate to the slave devices on the full-duplex connection, and the Slave Pair would be used by slaves for transmitting messages back to the master. This could happen simultaneously.

Cable Types

Master Used	Cable Type To Use For Testing	Notes
PC	USB to RS485 cable	RS485 cable should have stripped wires for connecting to terminal blocks on the CSC400 Controller
PLC – Programmable Logic Controller (eg: SCADAPack, ROC800 series)	CAT5E	Use a matched twisted pair for RS485A+/B- Eg: Blue for RS485A+ Blue with white stripe for RS485B-

Allowable Pairings of CAT5E Cable

Signal	CAT5E Cable Wire Color Twisted Pairs	Notes
RS485A + or Data +	Blue	
RS485B - or Data -	Blue with white stripe	
RS485A + or Data +	Green	
RS485B - or Data -	Green with white stripe	
RS485A + or Data +	Orange	
RS485B - or Data -	Orange with white stripe	

RS485A + or Data +	Brown	
RS485B - or Data -	Brown with white stripe	

The common ground connection should use a wire from an unused pair in the CAT5E cable.

Examples of USB to RS485 cables

Manufacturer	Part #	Length	Website	Available at
Moxa	UPort 1130/1130I or UPort 1150/1150I		www.moxa.com	www.moxa.com
FTDI Chip	USB-RS485-WE-5000-BT	5m	www.ftdichip.com	www.digikey.com, www.mouser.com
FTDI Chip	USB-RS485-WE-1800-BT	1.8m	www.ftdichip.com	www.digikey.com, www.mouser.com
Startech	ICUSB422	6ft	www.startech.com	www.startech.com

Industrial-Rated USB Hubs

Manufacturer	Part #	Website	Available at
Startech	ST4200USBM	www.startech.com	www.startech.com
Moxa	UPort 404, UPort 407	www.moxa.com	www.moxa.com

Wiring topology

For connecting multiple Modbus devices on to the same RS-485 bus, a “daisy-chain” wiring topology should be used (one long cable with short “stub” connections to each device). Ensure that short “stub” connections are made at each device to the main RS485 cable to reduce signal reflections and interference.

A “star” or “ring” wiring topology should not be used. An example of a “star” configuration would be separate, multiple cables branching out from the Master to each individual slave device. Only one cable should be connected at the Master end.

Line Polarization

Line Polarization enables a pullup resistor on the “Data A +” signal and a pulldown resistor on the “Data B –“ signal. It ensures that the bus is put into a known state with the “Data A +” signal High and the “Data B -” signal Low. Some RS485 receivers are susceptible to external noise or interference if the RS485 bus is not driven to a known state when the bus is idle (no device is driving a signal on the bus).

Line Polarization should only be enabled on one device on the RS485 bus, if necessary. Usually this is done at the end of the bus where the master device resides. The CSC400 Controller allows the implementation of Line Polarization via two DIP switches located on the top of the board.

Some PC software (or other Masters) will work with Line Polarization off, while others may need the non-inverting signal to be driven high during idle times on the RS485 bus. For example, the PC software Modnet for Modbus RTU will work with Line Polarization off but it shows an extra “0x00” byte received at the beginning and end of a Modbus packet. However, the Modbus Reader PC software shows a Frame Error received by the CSC400 Controller if no Line Polarization is turned on.

Termination

This type of termination refers to bus termination between the pairs, not the termination resistors used for Line Polarization. This termination connects signal “Data A +” to “Data B –” through a 120 ohm resistor.

An RS-485 bus should only be terminated at each end of the cable (at each device at the end of the cable). No other devices in-between the two devices at each end should have termination resistors installed or enabled.

The CSC400 Controller has a 4-pin DIP switch with the third switch from the top labeled “120ohm term”. This can be used to connect a built-in 120 ohm resistor. Simply push the third DIP switch to the right and the 120ohm termination resistor will be connected.

Number of Allowed Devices on the RS-485

The number of devices allowed on an RS-485 bus depends on a variety of factors: the total length of the wire, the wire gauge, the signaling characteristics or the “Unit Load” of each device on the bus (receiver input impedance, capacitance).

The CSC400 Controller uses newer RS485 transceivers with advanced fail-safe features. Due to these newer transceivers, the theoretical maximum number of devices allowed on the bus is 256 because the receiver’s input impedance is 96kohm which is $1/8^{th}$ the input impedance of older transceivers at 12kohm ($1/8^{th}$ of a “Unit Load”). The Modbus specification limits this theoretical maximum further to 247 devices allowed on an RS-485 bus.

Any Modbus system allows a minimum of 32 devices on the RS-485 bus without use of a repeater. More devices may be allowed depending on the characteristics of all devices on the RS-485 bus.

The CSC400 Controller allows more than 32 devices to be present on the RS-485 bus due to each transceiver occupying $1/8^{th}$ of a Unit Load on the bus. Since each installation is different, with different cable lengths and the potential for other devices to be present on the bus, the user needs to test out the maximum number of devices that can be placed on each RS-485 bus.

Slew Rate

The CSC400 Controller incorporates RS-485 transceivers with slew rate limited drivers. Slew rate refers to the speed at which a signal changes state from a 0 (Low) to a 1 (High) or from a High to a Low state. Slew rate limited drivers slow down the rise and fall times of a signal which help with reducing signal reflections, reducing EMI emissions, and possibly allowing a bus to work without termination resistors.

Unfortunately, with slower rise and fall times, the maximum communication speed (or baud rate) is reduced. The drivers on the CSC400 Controller can operate at a maximum rate of 115kbps but the maximum setting allowed in the CSC400 firmware is 38.4kbps (38400 baud, or raw bits per second).

Isolated (or Common) Ground

The “Isolated Ground” terminal on each CSC400 Controller is isolated from the onboard CSC400 ground. This isolated ground connection should be used to connect all common ground connections on all RS-485 devices on the bus. This common ground should be connected to earth or protective ground at one end of the RS-485 cable only (preferably), usually at the master device.

Due to the potential for large amounts of noise to be conducted onto the RS485 cable, an option is provided to connect the RS485 isolated ground to the CSC400 earth ground to shunt noise away locally instead of at the Modbus master. A solid ground connection should be made between a CSC400 earth ground terminal to an earth ground external to the CSC400 using a minimum 16AWG wire.

Appendix D - Modbus Communication Tests

The Modbus communication between a Master device and the CSC400 Slave should be tested once the CSC400 Controller Modbus cabling is installed to ensure proper operation. Each CSC400 Modbus Slave device should also have its Modbus Slave ID (address) changed to a unique value before field installation takes place.

Connect Modbus test cabling between the CSC400 Controller and a PLC (Programmable Logic Controller) or a PC, referring to the following tables:

Cable Connections to Use Depending on the Master Used For Testing

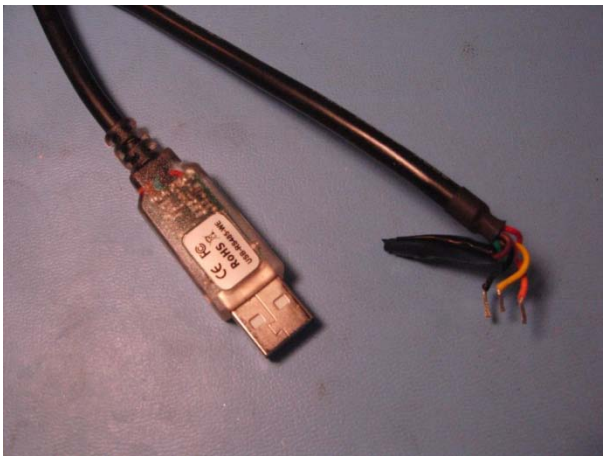
Master Used	Cable Connections	CSC400 Controller Terminal
PC	Data + (A)	"RS485A +" or "D0 A+"
	Data – (B)	"RS485B -" or "D1 B-"
	Ground	GND
PLC – Programmable Logic Controller (eg: SCADAPack, ROC800 series)	CAT5E pair + (Eg. Blue wire)	"RS485A +" or "D0 A+"
	CAT5E pair - (Eg. Blue with white stripe wire)	"RS485B -" or "D1 B-"
	CAT5E wire from an unused CAT5E pair	GND

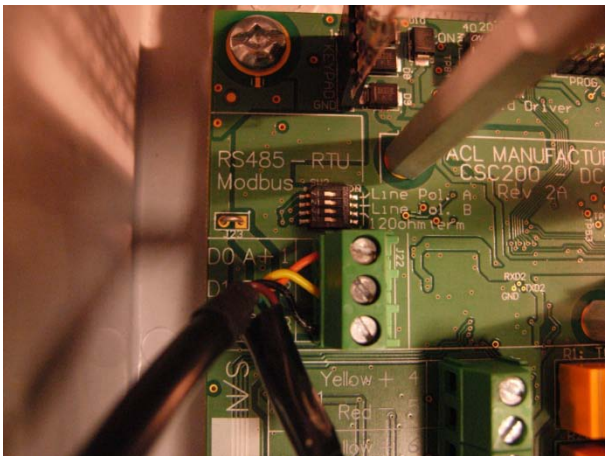
Example Cable Connection – PC Master

Cable used: FTDI Chip USB-RS485-WE-5000-BT, 5m, USB to RS-485 cable.

Cable Signal	FTDI Chip USB-RS485-WE-5000-BT (double-check these wire colors with the cable received)
Data + (A)	Orange wire
Data – (B)	Yellow wire
Ground	Black wire
Terminator 120ohm, pin 1	Brown wire
Terminator 120ohm, pin 2	Green wire

Figure 5 - FTDI Chip USB-RS485-WE-5000-BT USB to RS485 Cable, Installed with CSC400 Controller





Note that in this example, the unused wires are insulated from shorting to other parts of the CSC400 by using electrical tape to cover them.

If the termination resistor connections (brown and green wires) are not used on the FTDI Chip cable, it may be necessary to connect these two wires to the same “Isolated GND” ground terminal that the black ground wire is connected to. This prevents these wires from “floating” and potentially propagating noise down the RS485 cable.

Example Cable Connection – SCADAPack PLC Master

Figure 6 - CAT5E cable used

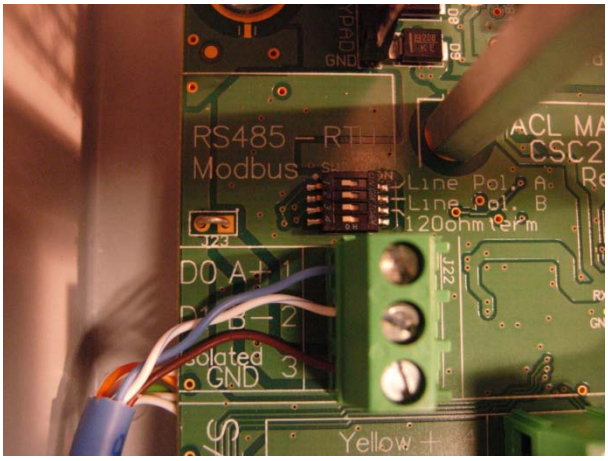


Figure 7 – SCADAPack 100

(SCADAPack 100 picture courtesy http://www.controlmicrosystems.com)

Figure 8 – SCADAPack 100 with CAT5E Cable Attached to COM1 (RS485 capable serial port)

Modbus Communication Test Using a PC Master

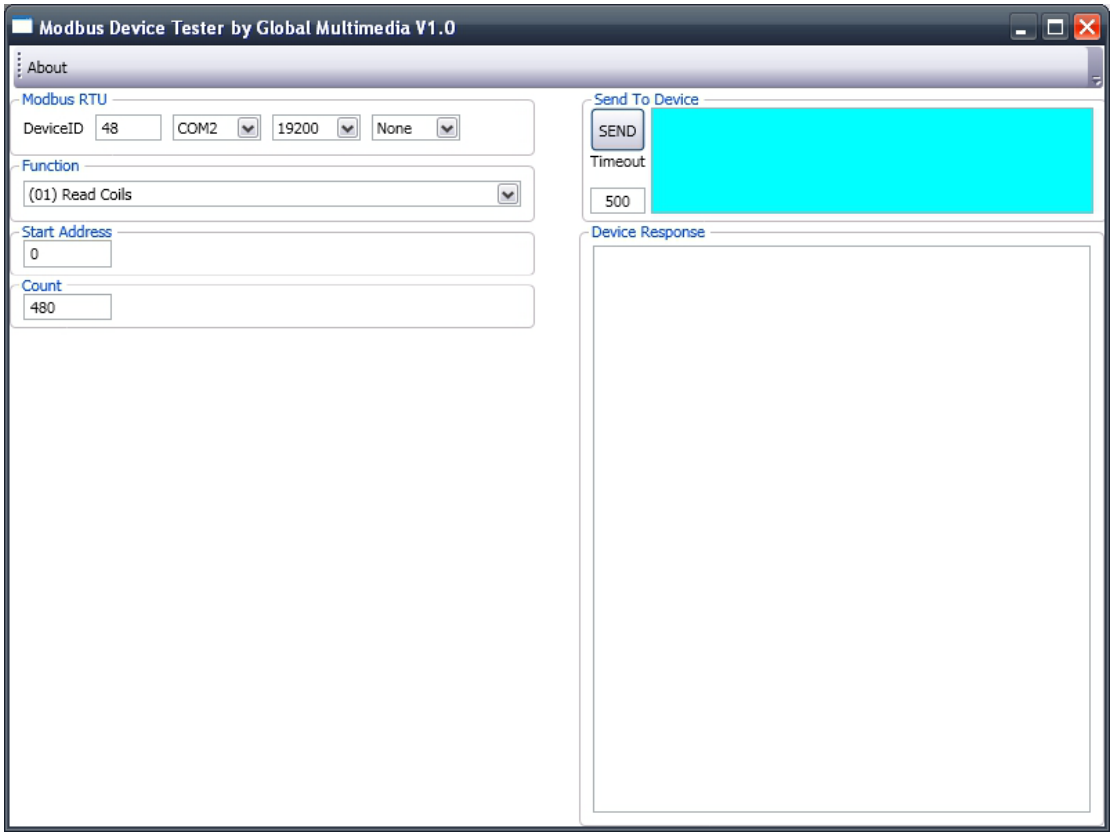
A variety of test programs are available for the PC for testing Modbus communications. A few are listed below:

PC Test Software	Company	License Type	Website
Modnet for Modbus RTU	Global Multimedia Private Ltd	Freeware	http://www.globalmultimedia.in/modnet.htm
Modbus Poll	Modbus Tools	30-day trial	http://www.modbustools.com/modbus_poll.asp
Modbus Constructor	KurySoft	30-day trial	http://www.kurysoft.com/products.shtml
Modbus Reader	KurySoft	Freeware	http://www.kurysoft.com/products.shtml

Additional technical resources for modbus can be found at the official Modbus Organization website: http://www.modbus.org/tech.php

The following procedure uses the PC software Modnet for Modbus RTU. The testing was done using a PC running Windows XP SP3 32-bit.

Figure 9 - PC Software Modnet for Modbus RTU



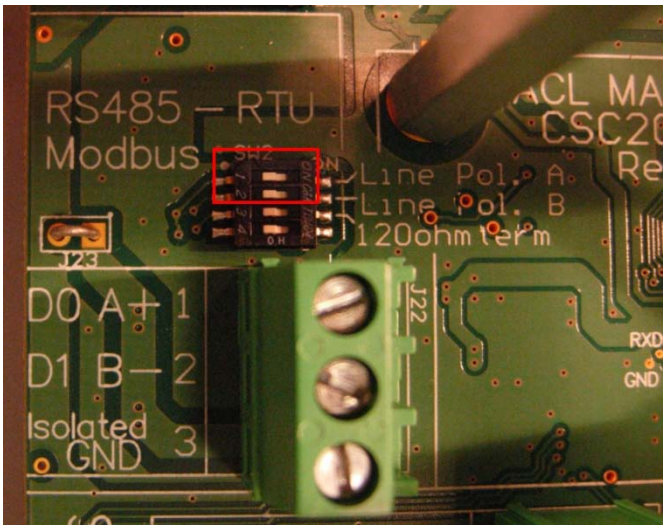
The test cable used was the FTDI Chip USB-RS485-WE-5000-BT, 5m, USB to RS-485 cable.

Figure 10 - FTDI Chip USB-RS485-WE-5000-BT, 5m, USB to RS-485 Cable

Test Preamble

For this test, the two "Line Polarization" DIP switches on the CSC400 Controller were turned ON, by moving them to the right (towards the "Line Pol…" text) as shown in the picture below (Figure 11).

Figure 11 – Line Polarization DIP Switches



"Line Polarization" enables a pullup resistor on the "Data A +" signal and a pulldown resistor on the "Data B –" signal. It ensures that the bus is put into a known state with the "Data A +" signal High and the "Data B -" signal Low.

Line Polarization should only be enabled on one device on the RS485 bus.

The PC software Modnet for Modbus RTU will work with Line Polarization on or off but there's a small difference in the response data received from the CSC400 using this software. Referring to the pictures below (Figure 12 and Figure 13), the data received shows an extra "0x00" at the beginning and at the end of the response packet.

Figure 12 - Modbus Response Data From CSC400 with Line Polarization ON

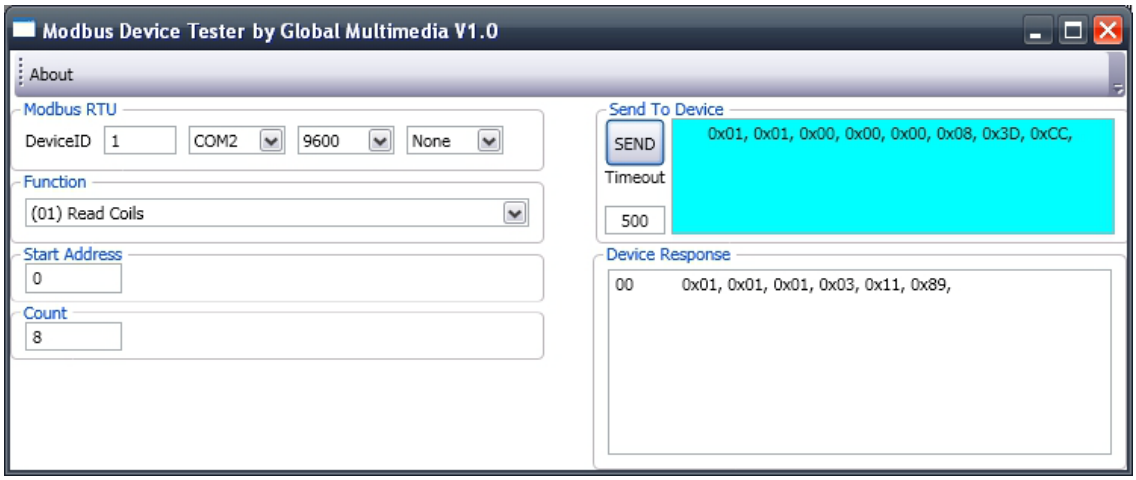
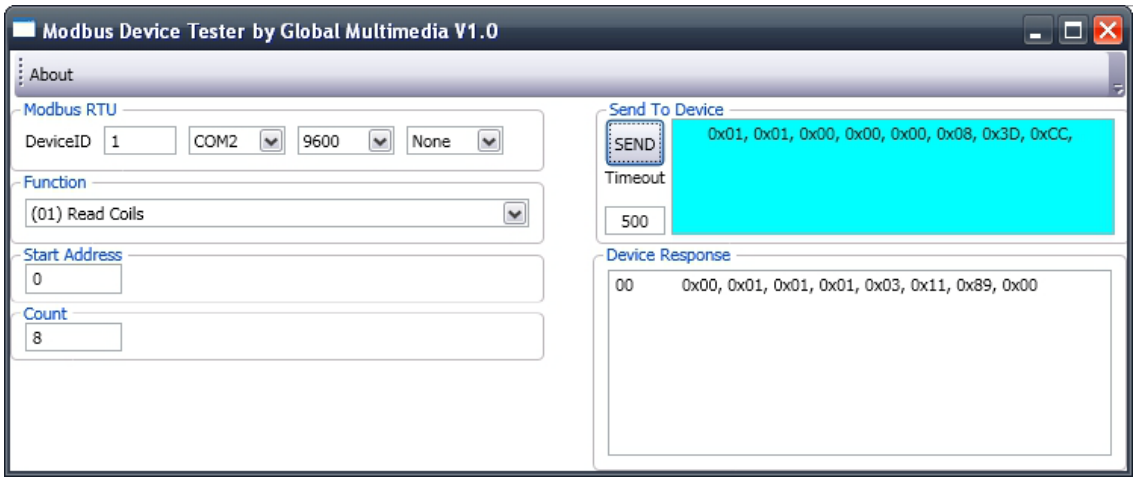


Figure 13 - Modbus Response Data From CSC400 with Line Polarization OFF

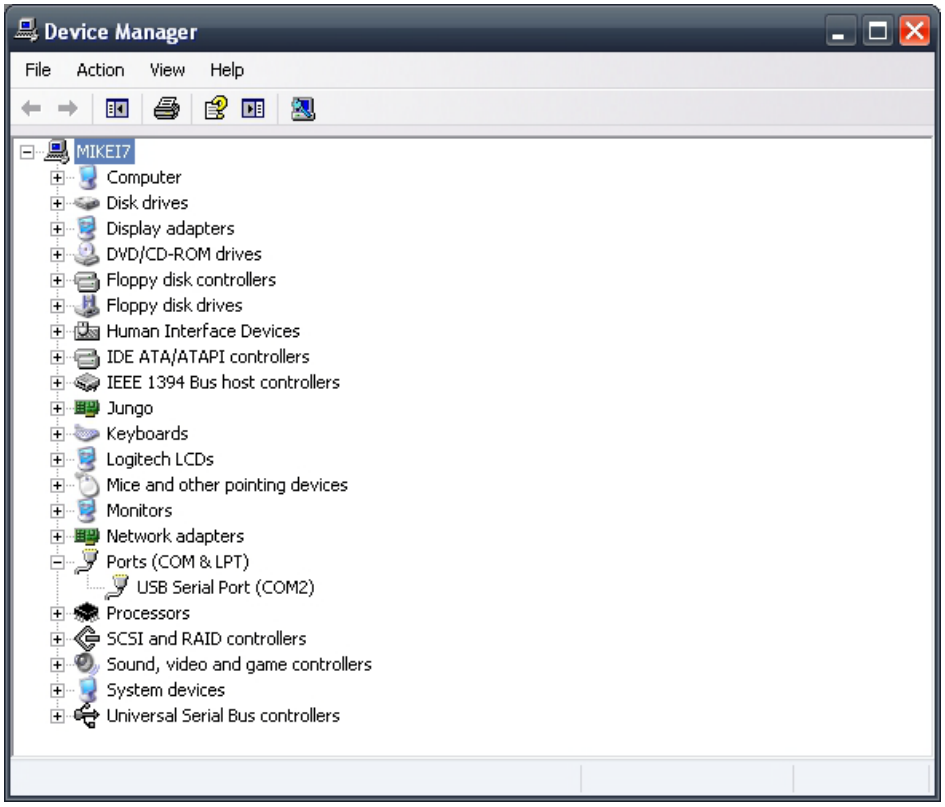


Test Procedure

1) Connect a USB-to-RS485 cable between the CSC400 Controller and the PC (refer to "Figure 5 - …. USB to RS485 Cable, Installed with CSC400 Controller" for details).

2) Ensure that the driver software for the USB to RS485 cable is installed and that the cable shows up as a virtual COM port in the Device Manager:
   - Press and hold the Left Windows Key, then press the Pause/Break key to display the System Properties window.
   - Click on the "Hardware" tab, then click on the "Device Manager" button. You should see the Device Manager window open, similar to the window shown in Figure 14.

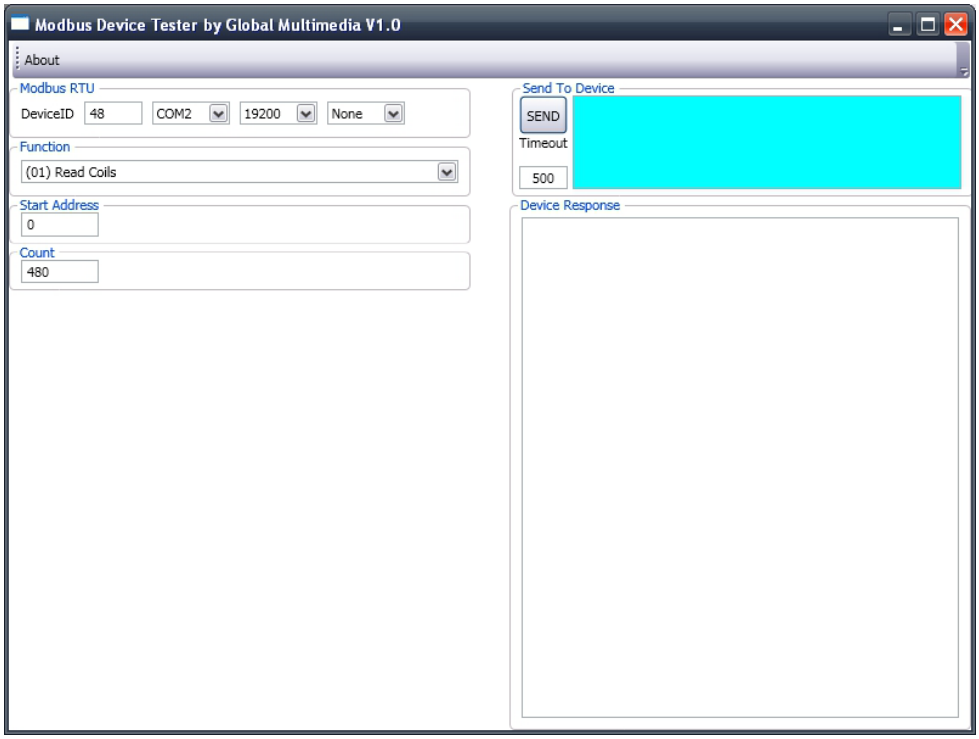
Figure 14 – Windows XP's Device Manager Window



"USB Serial Port (COM2)" is shown under "Ports (COM & LPT)"

3) Run the PC software Modnet for Modbus RTU. You should see a window similar to the one pictured in Figure 15 below.

Figure 15 - Modnet for Modbus RTU Software

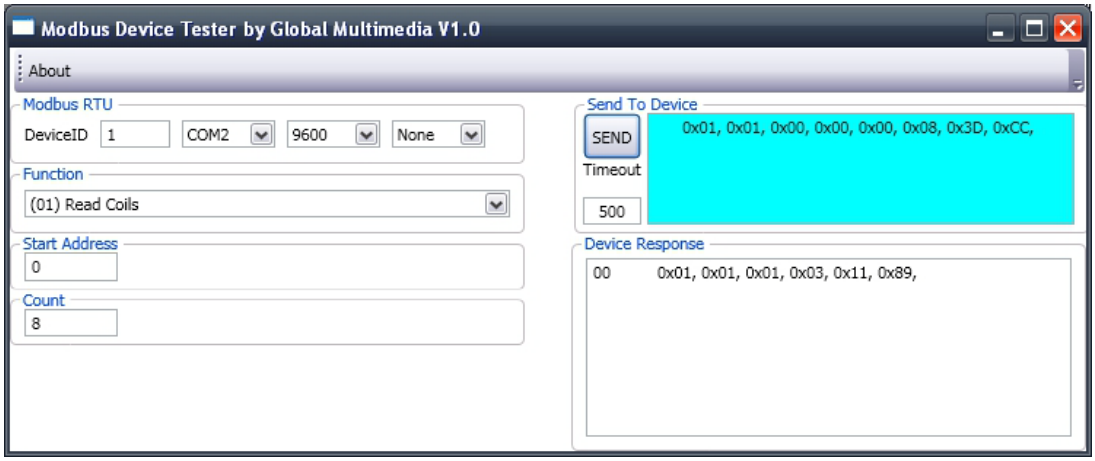


4) Change the default settings of the software to the following:
- Change DeviceID from “48” to “2” (default Modbus Slave ID for the CSC400)
- Make sure the same COM port shown in the Device Manager is selected here in the Modnet software (“COM2” in this case)
- Change the baud rate from “19200” to “9600”
- Change “Count” from “480” to “8”
- Leave all other settings at the defaults

5) Apply power to the CSC400. Wait for it to progress through its startup sequence. Once it shows a temperature on the LED display, proceed to the next step.

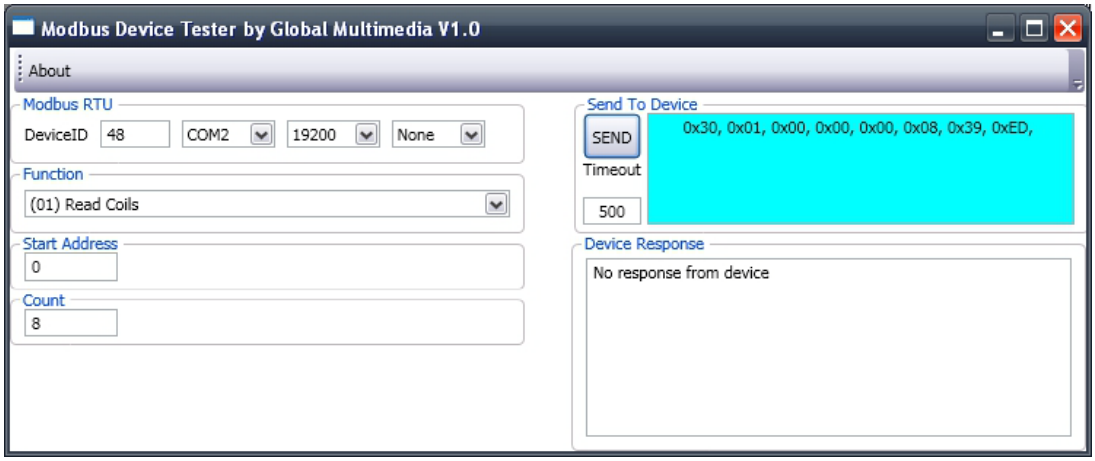
6) Click on the “Send” button. You should see a response from the CSC400 similar to the one shown in Figure 16.

Figure 16 – CSC400 Modbus Response to "Read Coils" Function Code



If you received no response, you will see something similar to the picture in Figure 17. (Notice that the settings weren't changed after first running the modnet software).

Figure 17 – Result from No Response to "Read Coils" Function Code



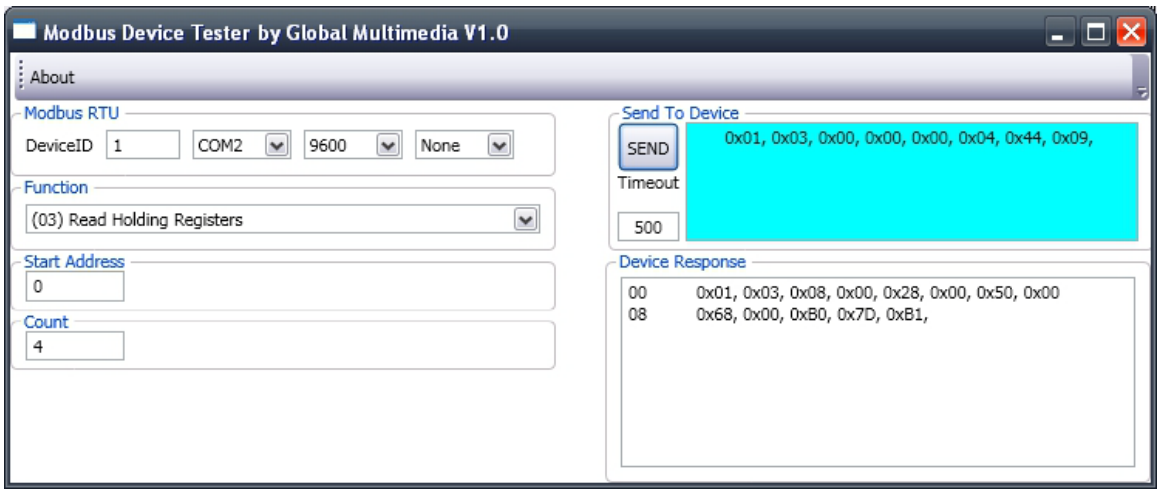
7) If a response was received where the first three bytes are all "0x01" (as seen in Figure 16), then the CSC400 Controller Modbus connections have been installed properly. You may proceed to the section titled "Programming a New Modbus Slave ID (Address)" to change the modbus Slave ID to the desired ID before installing this CSC400 in a field installation. Alternatively, you may also continue on to step 8, performing additional tests using the Modnet for Modbus software.

> If no response was received, double-check the wiring connections and the serial port settings. The default serial settings for the CSC400 Rev 2A Controller are 9600 baud, 8 data bits, no parity bits, and one stop bit. The default modbus Slave ID (address) is "2".

8) Change the settings of the modnet software to the following:
- Change the "Function" to "(03) Read Holding Registers"
- Change "Count" to "4"
- Leave all other settings as they are

9) Click on the “Send” button. You should see a response from the CSC400 similar to the one shown in Figure 18.

Figure 18 - CSC400 Modbus Response to “Read Holding Registers” Function Code



The response shows four 16-bit values returned which are the current setpoint temperatures in degrees Celsius and Fahrenheit :

Value in Hex	Value in decimal	Description
0x0028	40	TC1 temp setpoint (deg C)
0x0050	80	TC2 temp setpoint (deg C)
0x0068	104	TC1 temp setpoint (deg F)
0x00B0	176	TC2 temp setpoint (deg F)

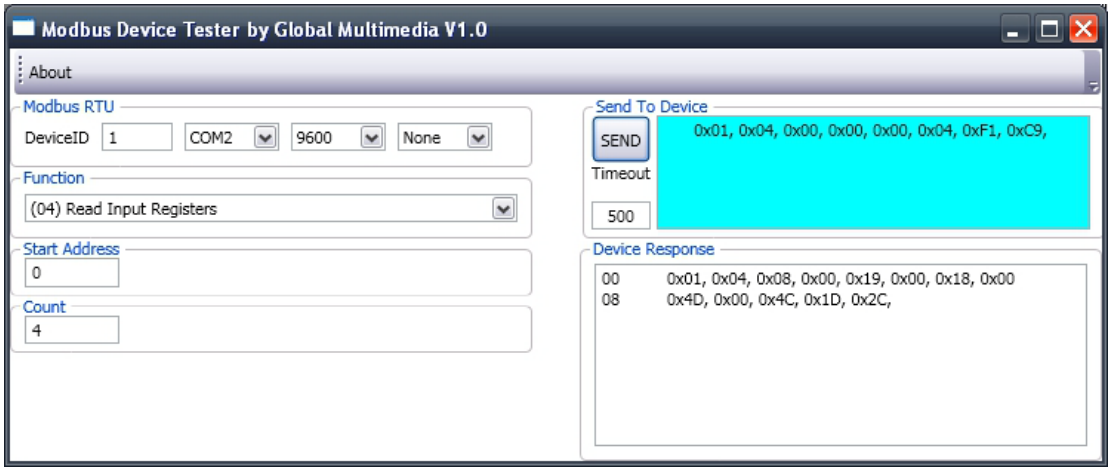
These values correspond to the current setpoint temperatures that we are viewing on the CSC400’s LED display, so we know that the modbus communication was successful.

Note that the last two bytes are for CRC (cyclic redundancy check) error checking.

10) Change the settings of the modnet software to the following:
- Change the “Function” to “(04) Read Input Registers”
- Leave all other settings as they are

11) Click on the “Send” button. You should see a response from the CSC400 similar to the one in Figure 19.

Figure 19 - CSC400 Modbus Response to “Read Input Registers” Function Code



The response shows four 16-bit values returned which are the current temperatures measured by the two thermocouples in degrees Celsius and Fahrenheit :

Value in Hex	Value in decimal	Description
0x0019	25	TC1 current temp (deg C)
0x0018	24	TC2 current temp (deg C)
0x004D	77	TC1 current temp (deg F)
0x004C	76	TC2 current temp (deg F)

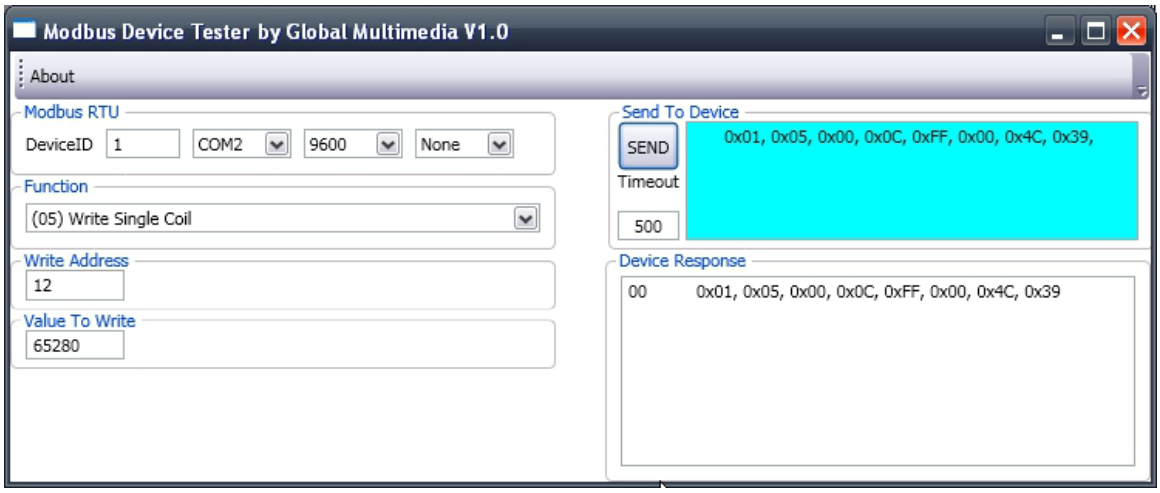
These values correspond to the current measured temperatures that we are viewing on the CSC400's LED display, so we know that the modbus communication was successful.

Note that the last two bytes are for CRC (cyclic redundancy check) error checking.

12) Change the settings of the modnet software to the following:
- Change the "Function" to "(05) Write Single Coil"
- Change the "Write Address" field to 12
- Change the "Value To Write" field to 65280 (0xFF00)
- Leave all other settings as they are

13) Click on the "Send" button. You should see a response from the CSC400 similar to the one in Figure 20.

Figure 20 - CSC400 Modbus Response to "Write Single Coil" Function Code



This function writes 0xFF00 to the "Coil" address for issuing a Remote Stop command to the CSC400. If the CSC400 was turned on, this command should've turned off the CSC400.

This test procedure showed how a variety of commands could be sent and received to the CSC400 using a PC with a USB-to-RS485 cable and the modnet for modbus diagnostic test software.

Modbus Communication Test Using a SCADAPack 100 PLC and Telepace Studio

A SCADAPack 100:1024k was used for testing Modbus communications between a PLC and the CSC400.

Telepace Studio version 5.0.3 from Schneider Electric/Control Microsystems Inc. was used for testing. Due to the size of the sample project used for this test procedure, a full license of Telepace Studio was required for this test. Smaller projects have been created to test individual commands sent to the CSC400 from the SCADAPack 100 using the evaluation version of Telepace Studio.

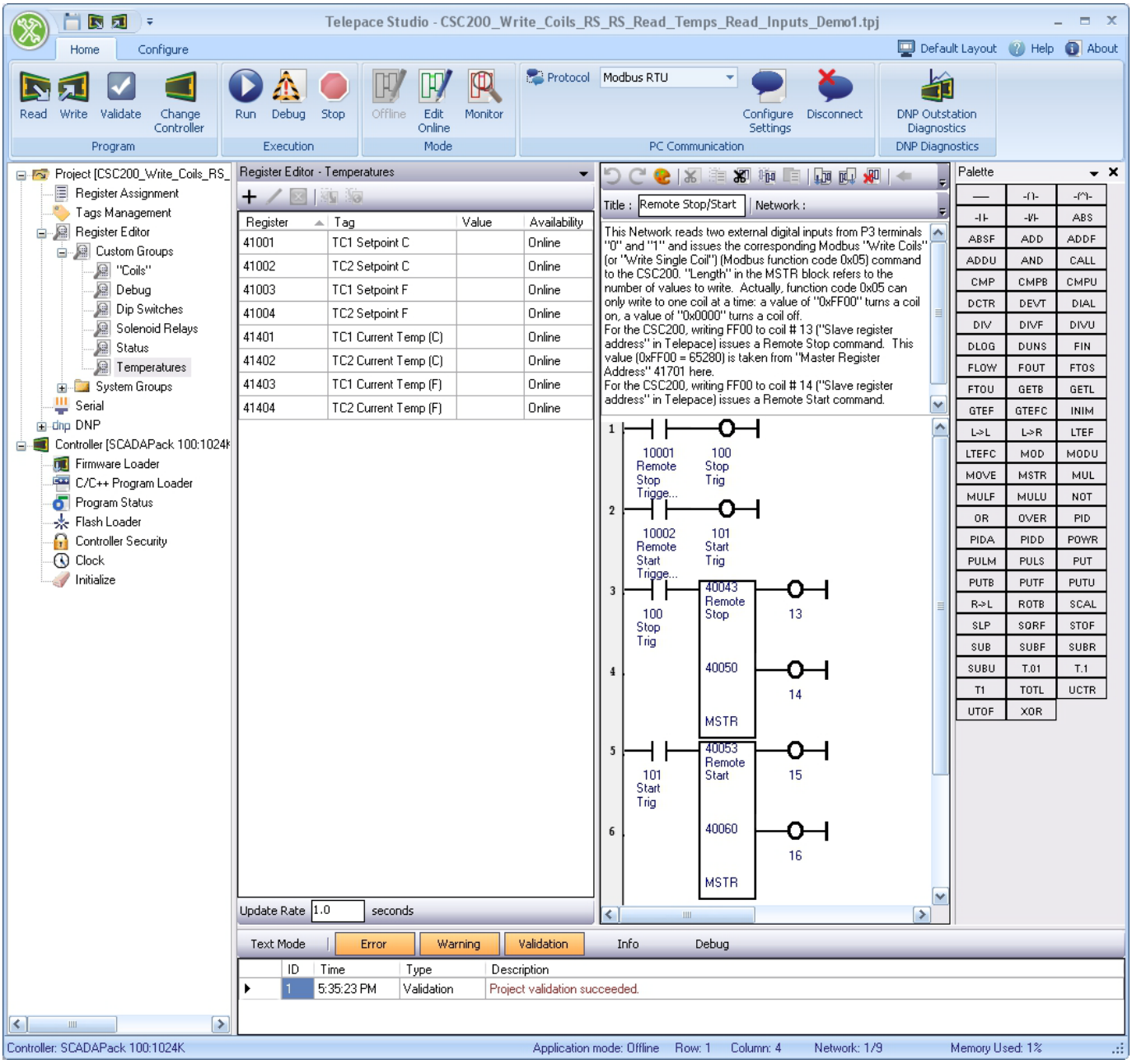
Figure 21 - SCADAPack 100 With Attached CAT5E Cable

The Telepace project used demonstrates all the commonly needed information read back from the CSC400. It periodically polls the CSC400 to read the coil status, the input registers, the discrete inputs, and some of the holding registers.

A SCADAPack 100:1024k Controller was used for this demonstration.

A CAT5E test cable between the SCADAPack and the CSC400 Controller was attached. Refer to Appendix C for additional details.

Figure 22 - Communication Test Demonstration Using a SCADAPack and Telepace Studio



Appendix E - Programming a New Modbus Slave ID (Address)

The default Modbus Slave ID for a new CSC400 is “2”.

The Modbus Slave ID for the CSC400 can be changed via the Modbus Settings menu.

Appendix F - PC Communication Test Demonstration: Modbus Reader Software

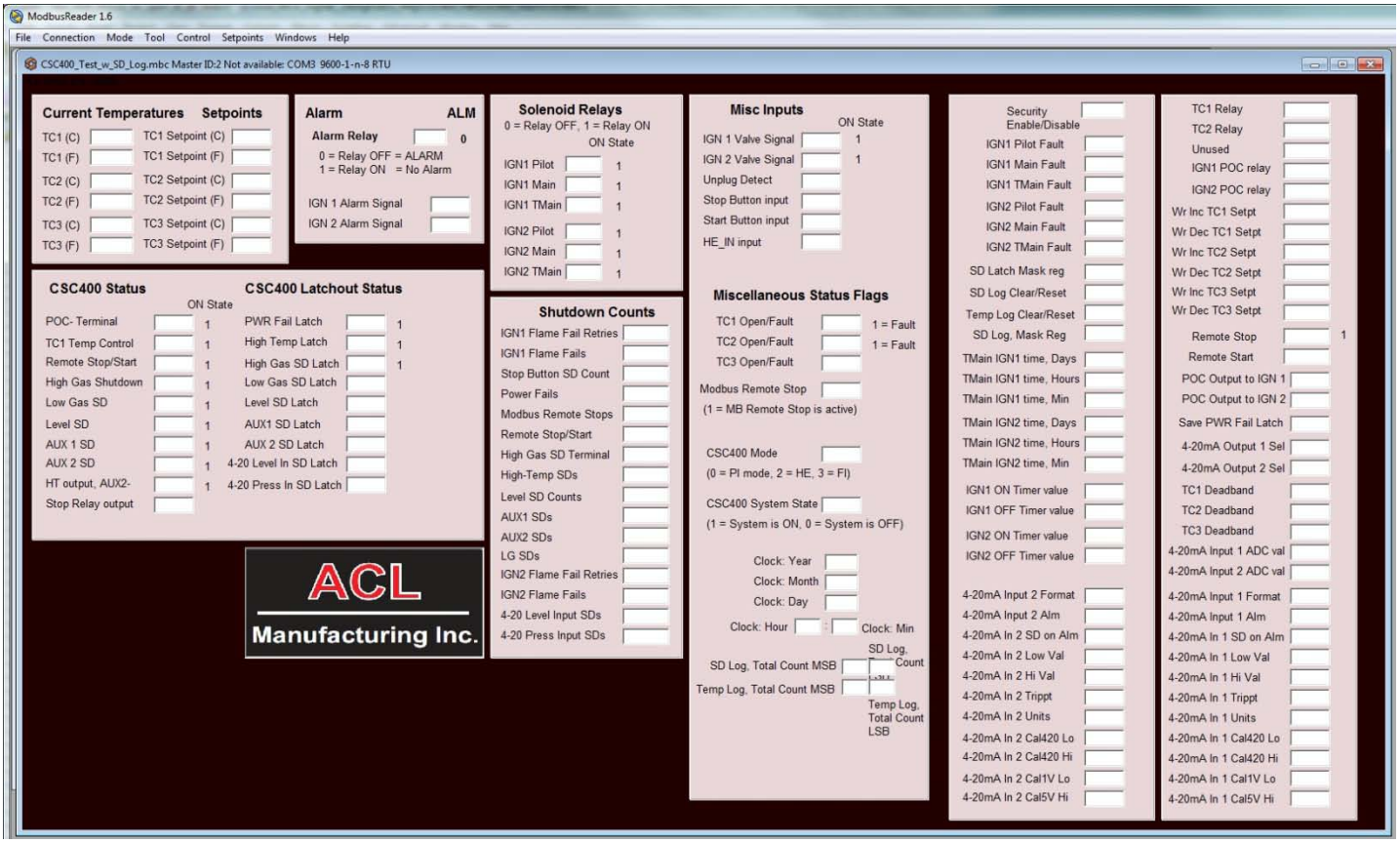
The program Modbus Constructor (includes Modbus Reader) was used to generate the project shown below in Figure 23. The license for Modbus Constructor is a 30-day free trial. It can be downloaded here http://www.kurysoft.com/products.shtml

Modbus Reader can be downloaded for free from http://www.kurysoft.com/products.shtml

1) This project demonstrates all the commonly needed information read back from the CSC400. It periodically polls the CSC400 to read the coil status, the input registers, the discrete inputs, and some of the holding registers.

2) The serial settings can be changed in the “Connection” menu then “COM Parameters” sub menu. The Slave ID (address) to communicate with can be changed in the menu item “Mode” --> “Master Settings”.

Figure 23 - CSC400_Test2_w_SD_Log.mbc Modbus Reader Sample Project



Appendix G - Modbus/RS-485 References

The Modbus protocol specification can be viewed here http://www.modbus.org/specs.php
"Modbus Protocol Specification", filename "Modbus_Application_Protocol_V1_1b.pdf")

The Modbus serial line protocol and implementation guide can be viewed here http://www.modbus.org/specs.php
"Modbus Serial Line Protocol and Implementation Guide", filename "Modbus_over_serial_line_V1_02.pdf")

Additional technical resources for modbus can be found at the official Modbus Organization website:
http://www.modbus.org/tech.php

Appendix H - Troubleshooting

#	Issue	Possible Reason	Corrective Action
1	Modbus Master can't read temperature values from CSC400 (or any other data)	RS485 cable isn't connected properly	Ensure the wires for the RS485 cable are connected properly at the CSC400 and at the master and that the screw terminals are gripping the metal wire, not the insulation. Wires may also become damaged with frequent bending or if they've been pinched. Ensure that the RS485 signal wires haven't been broken by testing continuity.
		Modbus Slave ID (address) is different than the address used for the CSC400	Verify that the address used by the master to communicate with the CSC400 matches the address set in the CSC400. Try using the default address: "2". The master may need to poll a variety of modbus addresses (from 1 to 247) to find slaves that respond.
		Power to the CSC400 may have been interrupted	Verify the CSC400 has power locally.
		Inappropriate, non-twisted pair cable has been used for the RS485, for long distances	Ensure that an appropriate twisted-pair cable (like CAT5e cable, or other appropriate cable) is used for the RS485 bus.
2	Modbus communication interrupted, noise issues suspected	Inadequate or ineffective grounding	Ensure that an adequate connection has been made between the earth ground terminal on the CSC400 and an appropriate earth ground external to the CSC400 (eg: thick spike in the ground, underground water pipes, earth ground pin on an AC wall outlet).
			Ensure that unused, non-power sourcing wires in any RS485cable are grounded.
			Connect the "Isolated GND" terminal on the CSC400 Controller to the CSC400 earth ground terminal to provide a localized ground path for noise. (Attach GND jumper on Rev 2B cards and later)
		Power to the CSC400 may have been interrupted	Verify the CSC400 has power locally.
3	Modbus PC Master communication with CSC400 interrupted	If a USB-to-RS485 conversion cable has been used, the PC test software may have lost connection to the virtual COM port, or noise may have interfered	Unplug the USB-to-RS485 conversion cable from the USB port on the PC, wait 10 seconds, then plug it back in. Retry connecting to the COM port in the test software.

		with USB communications.	
			Add an industrial-rated USB hub between the PC and the USB-to-RS485 cable. Ensure that the hub is powered locally, not bus-powered from the PC.
			Refer to Troubleshooting item # 2 for additional grounding notes
		Power to the CSC400 may have been interrupted	Verify the CSC400 has power locally.
4	Modbus communication works for writing Remote Stop, Remote Start, but no values are being read back	CSC400's ignition module may be "sparking".	The CSC400 will not respond to Modbus requests when the ignition module is powering its high-voltage sparker to ignite the Pilot.
		If a USB-to-RS485 conversion cable has been used, the PC test software may have lost connection to the virtual COM port, or noise may have interfered with USB communications.	Unplug the USB-to-RS485 conversion cable from the USB port on the PC, wait 10 seconds, then plug it back in. Retry connecting to the COM port in the test software.

Notes: