ACL Manufacturing
A Division of ClearRushCo

Installation Manual

for the

CSC200 Combustion Safety Controller

WARNING

This manual must be read in its entirety before installation of this controller. Installation must be performed by a qualified technician and must adhere to the standards set by the local regulatory authorities.

ACL is not responsible for the misuse or incorrect application of this product.

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Introduction

The ACL CSC200 is a leading edge combustion safety controller that provides burner ignition and full first out annunciation of all the shutdown inputs such as Level, High Temperature, Remote Shutdown, pressure, Proof of Closure, Flame Failure, power failure, and more. The CSC 200 monitors two separate thermocouple inputs that can be utilized for temperature control in process applications such as tanks, line heaters, re-boilers or any other application where accurate temperature monitoring and/or control is required. The system is designed to operate with or without a continuous pilot.

The two independent thermocouple temperature set points can be adjusted with the three membrane push buttons on the face of the controller. The 4 digit LED display shows the measured temperature values and the temperature setpoints. There are also separate LEDs indicating whether Thermocouple 1 or 2 is currently selected and whether the burner is off or on. Various initial user preferences can be configured through DIP switches including temperature ranges, shutdown latch control, temperature unit display, and dead band range selection.

The CSC200 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 CSC200 Controller is a Modbus Slave Device that implements the Modbus RTU protocol on an RS-485, half-duplex, physical connection. The default Modbus communication parameters are 9600 baud, 8 data bits, no parity bits, one stop bit ("8N1"), Modbus Slave ID (Modbus address) 2.

CSC200 Features

CSC200 Controller Features List	
•	No Programming required
•	12/24VDC operation. Solar capable as well.
•	Low power consumption (Power save mode operates as low as 1.2 Watts)
•	CSA approved for Class I, Div 2 locations
•	Operational ambient temperature of -40° to +60° Celsius
•	CSA approved C22.2 No 199-M89. Combustion safety controls and solid-state Ignitors for Gas & Oil burning equipment
•	CSA B149.3 - 15 compliant, meets NFPA standards
•	Type 4x enclosure, corrosive resistant and weatherproof
•	Modbus RTU (over RS485) communications capability
•	100% fail safe design
•	Local and Remote On/Off controls
•	First out annunciation of shutdowns
•	Safety lockout for high temperature setting
•	Onboard solenoid driver option for power reduction to solenoids and peak-hold solenoids
•	Onboard solenoid output short circuit detection and notification
•	Two adjustable type-K thermocouple inputs for monitoring two separate temperature points (process temp. & high temp.)
•	Pilotless burner control selectable. Single and dual stage, Low fire and High fire
•	Two Shutdown inputs: Low-Level Shutdown and Shutdown (ie. pressure shutdown)
•	Thermocouple range of -60°C to 1100°C (-75°F to 2012° F)
•	Adjustable dead band from 1, 2, 3 and 5 degrees C or 2, 4, 6 and 10 degrees F
•	Easy to read four digit seven segment LED display
•	LED indication of thermocouple 1 or 2 temperature values displayed and burner is on or off
•	°C or °F readout

Operation Summary

Supply 12/24VDC to Main Input Power connections on the CSC200 Controller, referring to "Figure 1 – CSC200 Controller Main Board, Top View" on page 4. The LED display will turn on and indicate the Thermocouple Temp 1 is being displayed. Select the desired thermocouple's temperature to display using the "1/2" thermocouple select push button. The up and down arrows set the desired temperature setpoint. Once temperature setpoints are set to the proper values for the desired process (heater, boiler, etc.), the On/Off switch can be turned to the On position.

When the ignition switch is turned on and the controller is calling for heat (measured temperatures are below the setpoint temperatures), the controller will attempt ignition and the pilot solenoid output will provide voltage to the pilot solenoid valve, providing pilot gas for ignition. Shutdowns, POC, and Remote On/Off terminals must be in a permissive state for this to occur. Pilot solenoid output will cease if there is a failure to light within five seconds. "FF" will appear on the display indicating "Flame Fail". When using a single-try ignition module, the controller will lockout and have to be reset. When using a three-try ignition module, the controller will attempt to light the pilot two more additional tries before locking out. This condition can be reset either by the local On/Off switch, the Remote On/Off switch, or via Modbus Remote Stop/Start command. Main solenoid valve outputs will be turned on 10 seconds after it is confirmed that the pilot has been lit.

The Intermittent/Continuous Pilot DIP switch selects the behavior of the controller once all solenoids are opened:

- In Pilotless/Intermittent pilot mode (I), once the measured temperature on thermocouple 1 reaches the TC1 setpoint temperature (but TC2 temp is still below the TC2 setpoint), all solenoid valves will be turned off.

- In Continuous pilot mode (C), once the measured temperature on thermocouple 1 reaches the TC1 setpoint temperature (but TC2 temp is still below the TC2 setpoint), only the T/Main solenoid valve is turned off. The Pilot and Main solenoid outputs will remain on as long as all shutdowns and POC remain permissive. This allows the pilot burner to remain on while the temperature-controlled Main valve (T/Main) is closed.

For both modes, thermocouple 2 is used as a "high-temp" shutdown safety control. All solenoid outputs and the ignition module will be turned off if the measured temperature on thermocouple 2 is above the TC2 setpoint.

The CSC200 has a hardware revision of 2A and firmware revision 3.0 (minimum).
Current firmware versions: 3.7 and 3.9.

Firmware v3.9: Regardless of DIP Switch "IGN 0 / 3" ("TC1 H/L") setting, initial attempt to light the pilot burner is done up to three times with either a one-try or three-try module. After flame presence is lost, the "IGN 0 / 3" ("TC1 H/L") setting is used: either zero or three retries to light the pilot.

THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS1 DIVISION 2, GROUPS A,B,C & D OR NON-HAZARDOUS 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:

Four position DIP switch SW2
Relays K1 – K5, K7, K8
Twelve-position DIP switch S1
Four-position DIP switch S2

Note: Ignition wire lengths in excess of 10' or use of metal or metallic sheathed conduit to convey the ignition wire may result in a diminished ignitor rod spark and flame signal strength.

Additional Documents

The following additional documents for the CSC200 Combustion Safety Controller are available.

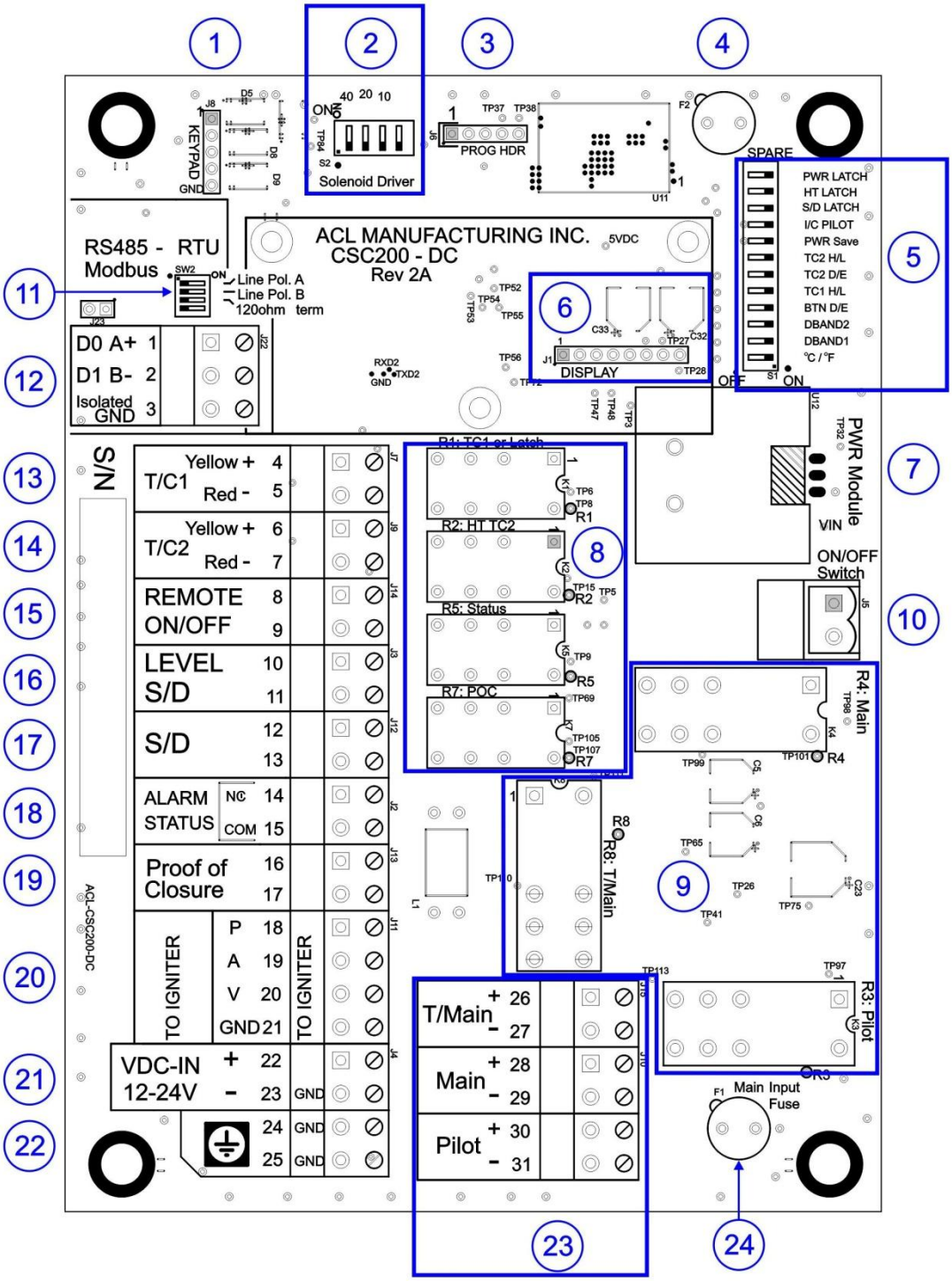
Document Filename	Document Description
CSC200_Rev_2A_Modbus_Installation_Manual.pdf	Modbus documentation containing more indepth register descriptions and additional technical details.

Quickstart Installation Procedure

CSC200 Combustion Safety Controller

> The Quickstart Installation Instructions assumes the user has some familiarity with Combustion Safety Controller Installation.

Figure 1 – CSC200 Controller Main Board, Top View

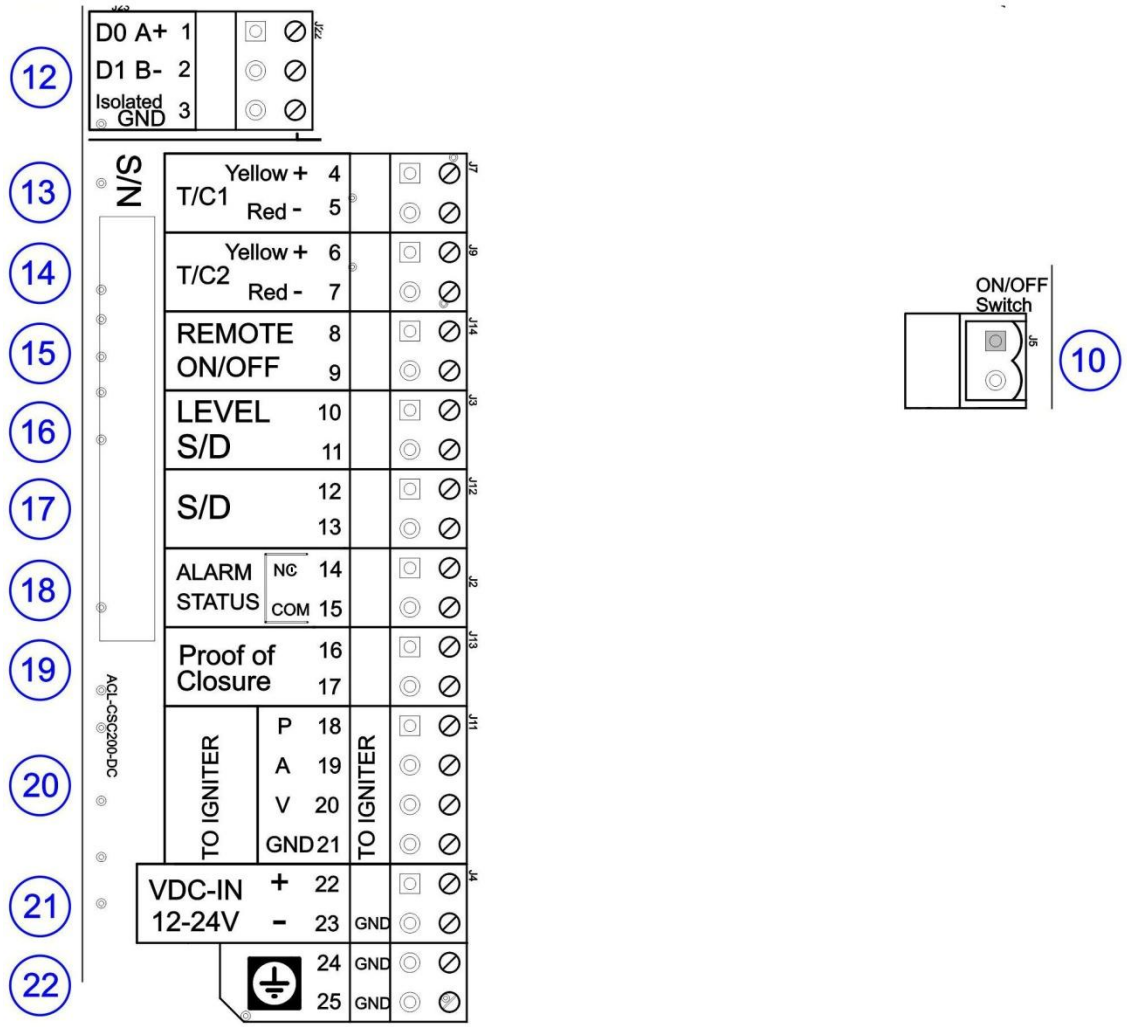


#	Name	Category	Description
1	Overlay (Keypad) Header	Inputs/Control	5-pin Header connector that the flex cable from the Keypad overlay on the front panel connects to.
2	Low Power Solenoid DIP Switches	Output Solenoids Control	DIP switches for selecting the Low Power solenoid driver settings for all three solenoid terminal outputs (see "Low Power Solenoid (Solenoid Driver) DIP Switch" section on page 21).
3	Programming Header	Programming	Programming header (factory use only) for reprogramming the onboard microcontroller.
4	Spare Fuse	Power	Spare 6.3A fuse for field servicing.
5	Main DIP Switches	Inputs/Control	DIP switches for user options configuration (see "DIP Switch Option Settings" section on page 19).
6	Display Header	Display	8-pin header connector that the CSC200 display flex cable connects to.
7	Input Power to 12VDC Power Module	Power	Power regulator that converts 10-30VDC input voltage to a stable 12VDC output voltage for control. (This 12VDC output is not used for outputting to solenoids).
8	Control Relays	Inputs/Control	Relays used for controlling power switching to ignition module and for alarm status.
9	Solenoid Relays	Output Solenoids	Relays used for controlling power delivery to the solenoid valves. Double-pole double-throw relays are connected in series to add an extra measure of safety in case one set of contacts fails while in the normally open position.
10	On/Off Switch terminals	Inputs/Control	On/Off switch on the side of the CSC200 box is connected to these terminals. Configured as a simple plug-in terminal to assist users if the CSC200 main circuit board needs to be removed for making modifications to the box.
11	Modbus DIP Switch	Modbus/RS485	DIP switches for selecting termination options for the Modbus/RS485 communications cable (See "Modbus/RS-485 Cable Connections" section on page 27)
12	Modbus Terminals	Modbus/RS485	Terminals for connecting a Modbus/RS485 communications cable. CSC200 is a Modbus RTU slave in a 8N1, 9600 baud default configuration.
13	Thermocouple 1	Inputs/Control	Thermocouple 1 input terminal connections. Ensure proper polarity for correct operation. Use ungrounded thermocouples.
14	Thermocouple 2	Inputs/Control	Thermocouple 2 input terminal connections. Ensure proper polarity for correct operation. Use ungrounded thermocouples.
15	Remote On/Off	Inputs/Control	Remote On/Off input terminal connections
16	Level Shutdown	Inputs/Control	Level Shutdown input terminal connections
17	Shutdown	Inputs/Control	Shutdown input terminal connections
18	Alarm Status	Alarm (Dry Contacts)	Alarm Status output terminal connections
19	Proof of Closure	Inputs/Control	Proof of Closure input terminal connections
20	"To Igniter" Ignition Module Terminals	Inputs/Control	ACL Ignition Module input terminal connections: "P"ower, "A"larm, "V"alve, Ground
21	Main Power Input Terminals	Power	Main 10-30VDC input terminal connections
22	Extra Earth Ground Terminals	Power	Extra earth ground terminal connections to assist in providing stable ground connections for solenoids, ignition modules, or other hardware
23	Solenoid Terminals	Output Solenoids	Solenoid output terminals for Pilot, Main, and T/Main (Temperature Main). Each output is current limited to 2A maximum.
24	Main Input Fuse	Power	Main 6.3A input fuse

Input and Control Connections

Refer to the below diagram when reading the Input and Control Connections section.

Figure 2 - CSC200 Input and Control Connections

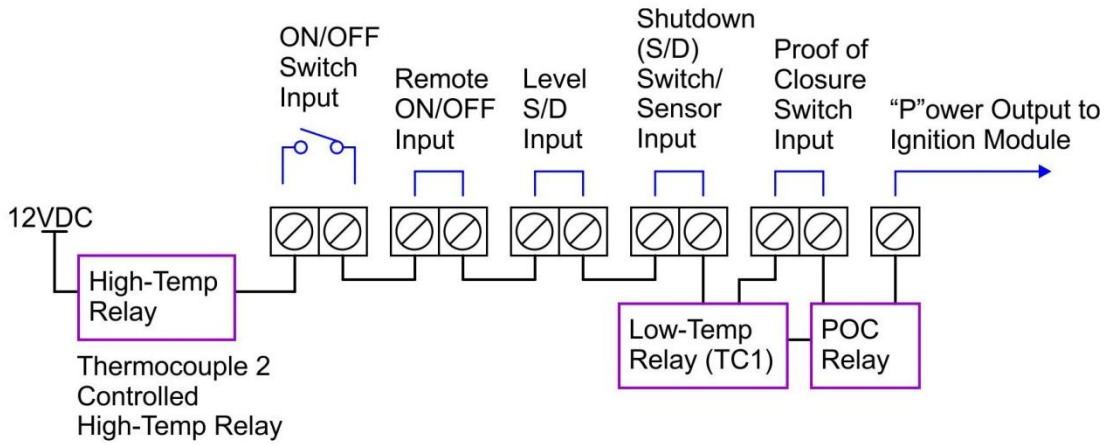


The following inputs directly control 12VDC power output to the ignition module and must be connected to dry contacts:

Input and Control Connections Requiring Dry Contacts
Main Power On/Off Switch (wired internally)
Remote On/Off
Level Shutdown
Shutdown
Proof Of Closure

Interruption or disconnection of any of these inputs will turn off or prevent power delivered to the ACL ignition module and turn off power to all solenoids with the exception of the Proof of Closure input. The Proof of Closure input will only interrupt power going to the ignition module if power has not been turned on to the ignition module. If the system is already running, the Proof of Closure input is allowed to open during operation.

Figure 3 - Ignition Module Power Flow Diagram



21 Main Power Input

The ACL CSC200 Combustion Safety Controller operates on an input voltage range between 10 and 30 Volts DC. Typical input voltages are 12VDC and 24VDC. Whatever input voltage is delivered to the CSC200 on the Main Power Input terminals is the same voltage delivered to the solenoid outputs. Solenoids attached to the three solenoid outputs on the CSC200 (Pilot, Main, T/Main) need to have matching control voltages (Eg. all 12VDC or all 24VDC).

Although the CSC200 will operate with input voltages as low as 10VDC, some larger solenoid valves may not operate on such a low voltage. For this reason, try to maintain the input voltage as close to (or slightly higher than) the required voltage for the desired solenoids.

The Main Power Input terminals are:

Terminal Number	Description	Typical Input Values	Allowable Input Range
22	VDCIN + (positive)	12VDC or 24VDC	10 VDC (min) - 30 VDC (max)
23	VDCIN - (negative)	0V (GND)	0V (GND)
24	Ground	0V (GND)	0V (GND)

The VDCIN - (negative) terminal is connected to ground internally on the CSC200 printed circuit board.

The Main power inputs (VDCIN + and VDCIN -) are protected against reverse polarity. The CSC200 will not operate if the Main Power Input wires are reversed and it will not cause damage to the CSC200 electronics.

10 Main On/Off Input Switch

The On/Off switch mounted on the side of the box of the controller is internally wired to J5 on the right side of the circuit board. The On/Off switch turns on and off the power delivered to the ignition module as long as all other shutdowns, Remote On/Off, and Proof of Closure inputs are closed and temperature values for both thermocouples are within the allowable range. It is not intended as a set of terminal wiring inputs needed by users.

As shown in the Ignition Module Power Flow Diagram above, the On/Off switch is the second method (but the first input) for interrupting power flow to the ignition module.

The On/Off switch also acts as a reset to clear any latched shut downs that have tripped and been detected by the CSC200. A shutdown configured as a latched shutdown prevents the system from automatically restarting after it detects any interruption in continuity on the input terminals for the selected shutdown. If a latched shutdown trips, then resets itself, the CSC200 will detect this, preventing the system from automatically restarting. The user will be alerted on the LED display (and via Modbus) as to which shutdown caused the latch out.

The CSC200 LED display will show "OFF" when the On/Off switch is in the Off position.

13 14 Thermocouple 1 and 2 Inputs ("T/C1", "T/C2")

The CSC200 controller accepts two type-K (ungrounded) thermocouples. They are clearly marked on the board for each thermocouple and polarity (See wiring diagram "Figure 5 - CSC200 Wiring Diagram" on page 24).

Terminal Number	Description	High Temperature Range	Low Temperature Range
4	T/C 1 Yellow +	-60°C to 1100°C (-76°F to 2012°F)	0°C to 500°C (-32°F to 932°F)
5	T/C 1 Red -		
6	T/C 2 Yellow +	-60°C to 1100°C (-76°F to 2012°F)	0°C to 500°C (-32°F to 932°F)
7	T/C 2 Red -		

The temperature range for each thermocouple can be selected via the DIP switches located in the top right corner of the main circuit board. Ranges can be selected independently for each thermocouple input, either high or low range. High temperature range is -60°C to 1100°C (-76°F to 2012°F). Low range is 0°C to 500°C (-32°F to 932°F).

15 Remote On/Off Input

The Remote On/Off switch allows the user to hard wire a remote switch or relay for controlling the CSC200. These terminals must be wired to dry contacts of a remote switch or relay when used. The Remote On/Off switch turns on and off the power delivered to the ignition module as long as all other shutdowns and Proof of Closure inputs are closed and temperature values for both thermocouples are within the allowable range. A wire jumper must remain across the Remote On/Off terminals when not in use.

As shown in the Ignition Module Power Flow Diagram on page 7, the Remote On/Off switch is the third method (but the second input) for interrupting power flow to the ignition module.

Like the main On/Off switch, the Remote On/Off switch also acts as a reset to clear any latched shut downs that have tripped and been detected by the CSC200. A shutdown configured as a latched shutdown prevents the system from automatically restarting after it detects any interruption in continuity on the input terminals for the selected shutdown. If a latched shutdown trips, then resets itself, the CSC200 will detect this, prevent the system from automatically restarting, and alert the user on the LED display (and via Modbus) as to which shutdown caused the latch out.

The CSC200 LED display will show "rr" when the Remote On/Off input is open.

Terminal Number	Description	Allowable Input Range
8	Remote On/Off +	None: use dry contacts
9	Remote On/Off -	None: use dry contacts

16 Level Shutdown Input

The Level Shutdown switch input allows the user to hard wire a remote level switch or relay for controlling the CSC200. These terminals must be wired to dry contacts of a remote level switch (or pressure or auxiliary switch) or relay when used. If

more than one shutdown switch is used, they must be wired in series. The Level Shutdown switch controls the power delivered to the ignition module as long as all other shutdowns and Proof of Closure inputs are closed and temperature values for both thermocouples are within the allowable range. A wire jumper must remain across the Level Shutdown terminals when not in use.

Opening of any switch attached to the Level Shutdown input will shut off the ignition module and de-energize all three valve outputs (Pilot, Main, TMain). Both the Level Shutdown and Shutdown inputs are tied into the control logic for the S/D Latch DIP switch. If the S/D Latch DIP switch is off, then it is in "Unlatched S/D" mode which means that the CSC200 will attempt to restart ignition when any switch attached to the Level S/D and S/D inputs clears. If the S/D Latch DIP switch is on, then it is in "Latched S/D" mode. A shutdown configured as a latched shutdown prevents the system from automatically restarting after it detects any interruption in continuity on the input terminals for the selected shutdown. If a latched shutdown trips, then resets itself, the CSC200 will detect this, prevent the system from automatically restarting, and alert the user on the LED display (and via Modbus) as to which shutdown caused the latch out.

As shown in the Ignition Module Power Flow Diagram on page 7, the Level Shutdown switch is the fourth method (but the third input) for interrupting power flow to the ignition module.

The CSC200 LED display will show "LLSd" when the Level Shutdown input is open.

Terminal Number	Description	Allowable Input Range
10	Level Shutdown +	None: use dry contacts
11	Level Shutdown -	None: use dry contacts

Shutdown Input (Pressure or Auxiliary)

The Shutdown inputs allow the user to hard wire a remote switch or relay for controlling the CSC200. These terminals must be wired to dry contacts of a remote switch (pressure or auxiliary) or relay when used. If more than one shutdown switch is used, they must be wired in series. The Shutdown switch turns on and off the power delivered to the ignition module as long as all other shutdowns and Proof of Closure inputs are closed and temperature values for both thermocouples are within the allowable range. A wire jumper must remain across the Shutdown terminals when not in use.

Opening of any switch attached to the Shutdown input will shut off the ignition module and de-energize all three valve outputs (Pilot, Main, TMain). Both the Level Shutdown and Shutdown inputs are tied into the control logic for the S/D Latch DIP switch. If the S/D Latch DIP switch is off, then it is in "Unlatched S/D" mode which means that the CSC200 will attempt to restart ignition when any switch attached to the Level S/D and S/D inputs clears. If the S/D Latch DIP switch is on, then it is in "Latched S/D" mode. A shutdown configured as a latched shutdown prevents the system from automatically restarting after it detects any interruption in continuity on the input terminals for the selected shutdown. If a latched shutdown trips, then resets itself, the CSC200 will detect this, prevent the system from automatically restarting, and alert the user on the LED display (and via Modbus) as to which shutdown caused the latch out.

As shown in the Ignition Module Power Flow Diagram on page 7, the Shutdown switch is the fifth method (but the fourth input) for interrupting power flow to the ignition module.

The CSC200 LED display will show "Sd" when the Shutdown input is open.

Terminal Number	Description	Allowable Input Range
12	Shutdown +	None: use dry contacts
13	Shutdown -	None: use dry contacts

18 Alarm Status Output

The Alarm Status output provides remote indication of an Alarm condition on the CSC200. These terminals are dry contacts. When power to the CSC200 is off, the Alarm Status contacts are open (between terminal 14 "NO" and terminal 15 "COM"), indicating an Alarm condition. The contacts are also open when the CSC200 is in a shutdown state. Eg: a shutdown switch is open, On/Off switch is open. This provides a complete fail-safe indicator to a remote control center of the status of the CSC200 controller.

Terminal Number	Description	Max Contact Rating
14	Alarm Status NO	Power: 60W, 62.5VA Voltage: 220VDC, 250VAC
15	Alarm Status COM	Power: 60W, 62.5VA Voltage: 220VDC, 250VAC

#	Possible Alarm Conditions
1	Power is off
2	On/Off switch is off
3	Remote On/Off switch is off
4	Level Shutdown switch is open
5	Shutdown switch is open
6	Proof of Closure valve is open
7	Flame Fail
8	High-Temp shutdown
9	Power Fail Latch condition
10	Shutdown Latch condition
11	High-Temp Latch condition
12	Modbus Stop command received
13	Thermocouple 1 (TC1) fault/open
14	Thermocouple 2 (TC2) fault/open
15	Short detected on solenoid valve output terminals

19 Proof of Closure Input

The Proof of Closure Input terminals are used when a proof of closure safety shutdown valve is used in a system. If the POC switch is open, it prevents power from being delivered to the ignition module. This safety feature eliminates the risk of igniting a burner if the POC valve is partially open and the proof of closure switch indicates open. This is also a failsafe input as it will not allow ignition to initiate if a wire is broken or disconnected.

These terminals must be wired to dry contacts of a remote Proof of Closure switch when used. A wire jumper must remain across the Proof of Closure terminals when not in use.

As shown in the Ignition Module Power Flow Diagram above, the Proof of Closure switch is the sixth method (but the fifth input) for interrupting power flow to the ignition module.

The CSC200 LED display will show "POC" when the Proof of Closure input is open.

Terminal Number	Description	Allowable Input Range
16	Proof of Closure +	None: use dry contacts
17	Proof of Closure -	None: use dry contacts

20 Ignition Module Inputs & Outputs

The four terminals marked as "To Igniter" on the main circuit board need to be wired directly to the ACL Ignition Module. This provides two-way communication between the CSC200 and the ignition module, creating a complete combustion safety control and burner ignition system. (See wiring diagram).

As shown in the Ignition Module Power Flow Diagram above, the "P"ower output to the ignition module can be interrupted by seven methods (shutdowns, on/off switches, temperature relays).

All of the below signals need to be attached between the CSC200 and the ignition module for the burner system to work properly.

Terminal Number	Designation	Description	Ignition Module Wiring Harness Color	Direction
18	P	Power (12VDC)	Red	Power output to Ignition Module
19	A	Alarm	Blue	Input signal from Ignition Module (12VDC level)
20	V	Valve	Brown	Input signal from Ignition Module (12VDC level)
21	GND	Ground	Yellow	Ground

12 Modbus / RS485 Communication Connections

The three Modbus/RS485 terminals are used for connecting the CSC200 Controller to a Modbus communications channel. The CSC200 Controller is a Modbus Slave Device that implements the Modbus RTU protocol on an RS-485, half-duplex, physical connection. The default Modbus communication parameters are 9600 baud, 8 data bits, no parity bits, one stop bit (“8N1”), Modbus Slave ID (Modbus address) 2.

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:

CSC200 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

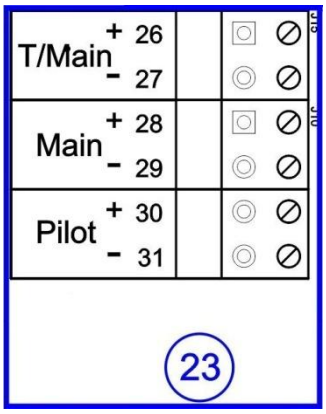
Due to the potential for large amounts of noise on the Modbus communication cable, the “Isolated Ground” terminal is connected to earth ground on the CSC200 board to improve noise immunity.

Refer to the "Modbus/RS-485 Cable Connections – Field Installations" section on page 27 or the document "CSC200_Rev_2A_Modbus_Installation_Manual.pdf" for more details on additional Modbus registers, programming, testing, and troubleshooting.

Solenoid Output Connections (23)

The solenoid output connections are designed for driving external solenoid valves. Each output is rated for a maximum of 2A current output. The main input voltage (either 12VDC or 24VDC) is fused and then directed through relays, current sense circuits for each output, low power driver circuits, and then output to each solenoid terminal.

Note: All solenoid outputs use the same Low Power Solenoid DIP switch setting. Therefore, the Low Power Solenoid DIP switches need to be set to the setting required to ensure that the solenoid(s) with the highest power requirement remain open when desired.



Pilot Solenoid

The Pilot Solenoid terminals provide power to the Pilot Solenoid valve as long as all shutdowns are in a permissive state. The Pilot valve allows gas to flow through the pilot valve train for initial ignition and flame sensing. During normal operation, the CSC200 turns on 12VDC power to the ignition module which begins a trial-for-ignition period. During this ignition period, the CSC200 reads the Valve signal returning from the ignition module and turns on the pilot solenoid output (12 or 24VDC) if this signal is high. The ignition module controls the direct spark ignition and performs flame sense of the pilot flame. The pilot's flame needs to be stable before the Main and T/Main solenoid outputs are turned on.

The pilot solenoid output has a low power feature provided by an onboard solenoid driver circuit. This circuit can reduce power consumption of the solenoids by as much as 80%. This circuit also helps eliminate any noise that may be produced by some solenoids, and helps extend the life of the solenoids.

For more information on the Low Power Solenoid Driver, see the Low Power Solenoid (Solenoid Driver) DIP Switch section on page 21.

Main Solenoid

The Main Solenoid terminals provide power to the Main Solenoid valve. Power to these terminals is provided 10 seconds after the pilot's flame is detected (and is stable) and the shutdowns are satisfied. The Main Solenoid valve is the first to open after the pilot flame is confirmed as being stable and remains open until a shutdown is triggered.

The Main Solenoid output also has the same low power solenoid feature provided by an onboard solenoid driver circuit. For more information on the Low Power Solenoid Driver, see the Low Power Solenoid (Solenoid Driver) DIP Switch section on page 21.

T/Main (Temperature Main) Solenoid

The Temperature Main ("T/Main") Solenoid terminals provide power to the T/Main solenoid valve. Power to these terminals is provided 10 seconds after the pilot's flame is detected and the shutdowns are satisfied. The T/Main solenoid valve is also controlled by the measured temperature on Thermocouple 1 (TC1). This allows for individual temperature control of one of the main solenoids (T/Main) based on the TC1 setpoint temperature, eliminating unnecessary stroking of the main safety shutdown valves to control main gas to the burner. If only one main fuel shut off valve is utilized in the valve train, it should be wired to the T-Main Solenoid valve output.

The T/Main Solenoid output also has the same low power solenoid feature provided by an onboard solenoid driver circuit. For more information on the Low Power Solenoid Driver, see the Low Power Solenoid (Solenoid Driver) DIP Switch section on page 21.

Intermittent (Pilotless) or Continuous Pilot Feature

The CSC200 incorporates a feature that allows the user to select between Pilotless/Intermittent Pilot (I) or Continuous pilot (C) modes for burner control using a DIP switch setting ("I/C Pilot"). See the Main DIP Switch section on page 19 for details.

Intermittent / Pilotless Pilot (I)

The ACL CSC200 controller provides the Intermittent/Pilotless Pilot feature for applications where a continuous pilot may not be desirable. The pilot output is only energized when the controller is calling for heat (the measured temperature on thermocouple 1 is below the TC1 setpoint temperature). In this case, the pilot turns on, then after 10 seconds the Main and T/Main outputs become energized. This allows for a low fire start through the main burners or a pilot/main start where an individual pilot and main are used. This is only initiated if the On/Off switch is in the On position and all shutdowns and POC are closed.

Continuous Pilot (C)

When Continuous Pilot (C) is selected via the DIP switch settings, the pilot output becomes energized when the On/Off switch is turned to on, and all shutdowns and POC are clear and permissive, regardless of whether the controller is calling for heat.

Once the Pilot turns on, 10 seconds later the Main and T/Main solenoid outputs become energized, if calling for heat. When the TC1 setpoint is reached, the T/Main output turns off and the Pilot and Main outputs stay energized.

Adjusting Temperature Setpoints

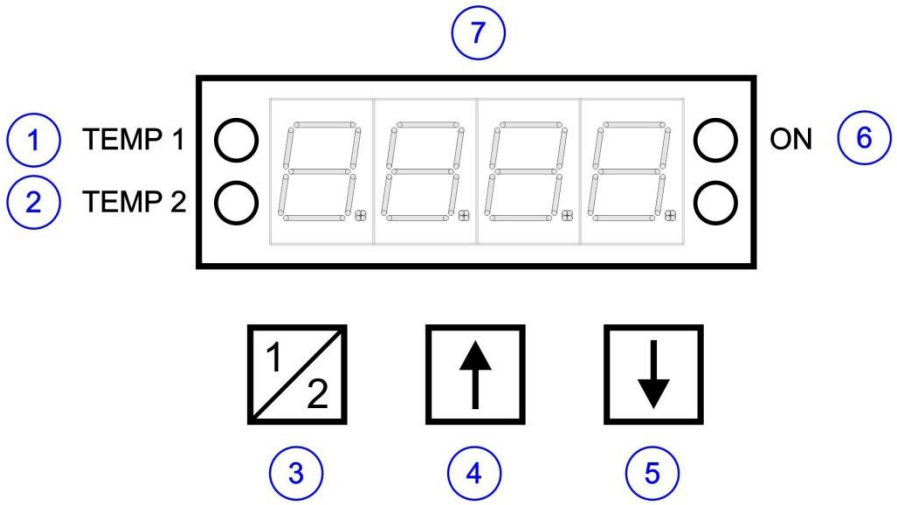
The CSC200 Controller provides a simple status and control interface to the user on the overlay mounted on the outside of the CSC200's box. Three status LEDs and a 4-digit, 7-segment LED display provide status and feedback while three membrane push buttons provide control for setting temperature setpoints.

After setting the setpoints, the display will revert back to show the actual thermocouple temperature reading after two seconds. The temperature displayed and the setpoint modified will always correspond to the selected thermocouple indicated by the Temp 1 or Temp 2 LED.

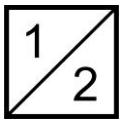
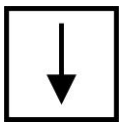
The 4-digit, 7-segment display will show "- - - -" when thermocouples are not enabled through the designated DIP switch.

The 4-digit, 7-segment display will show "OPEN" if the thermocouples are not connected or if they have failed in an open condition.

Figure 4 - CSC200 Controller Front Panel Overlay

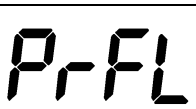


#	Indicator LED(s)	Description
1	Thermocouple 1 / Temperature 1	Green LED indicating that either the measured temperature or setpoint temperature for Thermocouple 1 is being displayed on the 4 digit 7-segment display.
2	Thermocouple 2 / Temperature 2	Green LED indicating that either the measured temperature or setpoint temperature for Thermocouple 2 is being displayed on the 4 digit 7-segment display.
6	Flame ON	Green LED indicating that the controller is providing power to the ignition module and that at least one of the solenoid outputs (Pilot, Main, T/Main) is on (a flame is present).
7	4 Digit, 7-Segment Display	Displays the temperature for thermocouples 1 and 2 and provides a variety of status messages to the user.

#	Overlay Button	Description
3		Selects between displaying temperature of Thermocouple input 1 or 2 (TC1 or TC2) on display Temp 1 - Bath or process temperature Temp 2 - High temperature shutdown Also controls displaying of TMain solenoid ON time (see page 17) when held in for 5 seconds.
4		Displays and increases temperature setpoint for the selected Thermocouple. Hold button down to increase setpoint by larger increments. Release button when desired setpoint is reached. Display will then return to actual temperature reading for the selected Thermocouple after 2 seconds.
5		Displays and decreases temperature setpoint for the selected Thermocouple. Hold button down to decrease setpoint by larger increments. Release button when desired setpoint is reached. Display will then return to actual temperature reading for the selected Thermocouple after 2 seconds.

CSC200 Controller 4-Digit, 7-Segment LED Display Codes

The following table provides a summary of all the possible Display codes that the user may see on the CSC200 Controller's 4-digit 7-segment LED display.

LED Display Indicator	Name	Description and/or Corrective Action if Necessary
Common Operational Messages		
	Power Fail	Indicates there was a power failure on the main input power to the controller. Seen upon first power-up as well.
	Power Fail Latch	Indicates there was a power failure on the main input power to the controller. Seen if the Power Fail Latch DIP switch is set to ON and a power failure occurs. A toggling of the On/Off switch, the Remote On/Off switch, or the Modbus Remote Stop/Start is required to reset this condition.
	Flame Fail	Indicates that the pilot has gone out and/or failed to re-light. Toggle the On/Off switch, Remote On/Off switch, or Modbus Remote Stop/Start to retry the ignition sequence.
	Temperature Reading or Temp Setpoint	Measured Temperature or Temperature Setpoint of the selected thermocouple ("Temp 1" or "Temp 2" LED indicates which thermocouple is currently selected) in degrees Celsius or Fahrenheit.
	Power is Off	Indicates that the main power "On/Off" switch is in the Off position (switch is open).
	Remote Reset	Indicates that the "Remote On/Off" switch is in the Off (open) position. Jumper with a wire jumper when not used.

	Low Level Shutdown	Indicates that the "Low Level Shutdown" switch inputs (or terminals) are open (in shutdown). Jumper with a wire jumper when not used.
	Shutdown	Indicates that the "Shutdown" switch inputs (or terminals) are open (in shutdown). Jumper with a wire jumper when not used.
	Proof of Closure	Indicates that the "POC" input is open, preventing power from going to the ignition module and allowing the system to start.
	High Temperature Shutdown	Indicates that the measured temperature on TC2 is at or above the setpoint, thereby shutting off all solenoid valve outputs (Pilot, Main, T/Main). May also indicate that the system is in High Temp Latch mode if the "HT Latch" DIP switch is set to On. A toggling of the On/Off switch, the Remote On/Off switch, or the Modbus Remote Stop/Start is required to reset this condition.
	Modbus Remote Stop	Indicates that the CSC200 has received a Modbus Remote Stop command and is waiting for either a Modbus Remote Start command, or a toggling of the On/Off or Remote On/Off switch before the system will start again.
Error Message Indicators		
	TC2 Thermocouple Disabled	Indicates that the selected thermocouple (TC2) is not enabled through the designated DIP switch ("TC2 D/E").
	Selected Thermocouple is Open or Failed Open	Indicates thermocouples are not connected or that they have failed in an open condition. Solenoid valve outputs will not open and the CSC200 system will not start until the thermocouple "OPEN" condition is fixed.
	Uncalibrated	Indicates that the CSC200 Controller's thermocouples are uncalibrated. Seen only upon startup after a power failure if the CSC200 is not calibrated.
	Pilot Solenoid Output Fail	Pilot solenoid output has failed but it's supposed to be open. ie: no output voltage is present on the Pilot + terminal
	Solenoid Fault - Pilot	There has been a fault on the Pilot Solenoid output due to a short circuit or excessive current draw on the Pilot + terminal (to ground).
	Solenoid Fault - Main	There has been a fault on the Main Solenoid output due to a short circuit or excessive current draw on the Main + terminal (to ground).
	Solenoid Fault - TMain	There has been a fault on the T/Main Solenoid output due to a short circuit or excessive current draw on the T/Main + terminal (to ground).
	TC1 Fault, Continuous Pilot Mode	TC1 has shut off power to the ignition module in Continuous Pilot mode due to a fault condition on thermocouple 1.

ErC1		The Thermocouple 1 (TC1) Calibration ratio is outside the valid range. The CSC200 needs to be recalibrated. The CSC200 will still work properly but the temperature measurements may be slightly different from actual temperatures.
ErC2		The Thermocouple 2 (TC2) Calibration ratio is outside the valid range. The CSC200 needs to be recalibrated. The CSC200 will still work properly but the temperature measurements may be slightly different from actual temperatures.
Er 12		The Calibration ratio for both thermocouples 1 and 2 (TC1 and TC2) is outside the valid range. The CSC200 needs to be recalibrated. The CSC200 will still work properly but the temperature measurements may be slightly different from actual temperatures.
POFn		"Pilot output failure" when Main is about to turn on - The pilot output is either off when it's supposed to be on as the Main solenoid is about to turn on (possible short on pilot output), or there's a failure in reading the pilot output (possible internal board error)

CSC200 Controller T/Main Solenoid Timer On Message Sequence

By performing a simple sequence on the button keypad, the total time that the T/Main Solenoid has been on can be displayed on the CSC200 Display. This can be used to help users calculate heat or energy output for the valve controlled by the T/Main solenoid.

Hold only the "1/2" (TC select) button in for five seconds to start this sequence.

Sequence State Number	TMain Solenoid Timer On Messages	Description
1	SOL	"Solenoid" - T/Main Solenoid Display mode starts
2	t ON	Time on
3	6 (Eg: Time in days)	T/Main on time in days (0 to 9999)
4	dAYS	"Days"
5	15 (Eg: Time in hours)	T/Main on time in hours (0 to 23)
6	Hr S	"Hours"

7	 (Eg: Time in minutes)	T/Main on time in minutes (0 to 59)
8		"Minutes"
9	(Sequence is Complete)	Current Temperature will then be displayed for the selected thermocouple

To reset the T/Main Solenoid "ON" time (to all zeros) using the keypad, perform the following sequence:

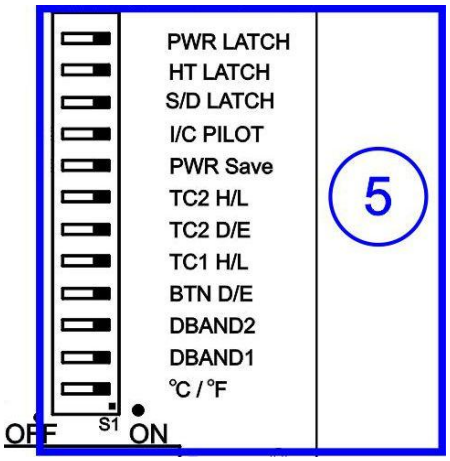
- Hold the "1/2" button in for five seconds until the "SOL" message shows on the display
- Continue holding the "1/2" button while now pressing and holding the "down" button for another 4 seconds.
- The following sequence will occur to inform you that the T/Main solenoid "ON" time was reset:

Sequence State Number	TMain Solenoid Timer Reset	Description
1		"Solenoid" - T/Main Solenoid
2		Time reset to all zeros for Day, Hours, Minutes
	(Done)	Current Temperature will then be displayed for the selected thermocouple

DIP Switch Option Settings

Main DIP Switch (S1, 12-pin)

For the main DIP switches, an "OFF" setting means the DIP switch is moved to the left. An "ON" setting means the DIP switch is moved to the right.



DIP Switch Number	Name on Circuit Board	Description	OFF	ON	Operation
12	PWR LATCH	Power Fail Latch	(Default)		Power Fail Latch mode is Off. The CSC200 will attempt ignition restart automatically after powerup sequence is done, provided that all shutdowns are clear and no other issues are detected.
					Power Fail Latch mode is On. The CSC200 will wait in Power Fail Latch mode and not attempt ignition restart until the On/Off switch, Remote On/Off terminal, or Modbus Remote Stop/Start is toggled Off, then On. "PrFL" will flash on the display.
11	HT LATCH	High Temp Latch			High Temperature Latch mode is Off. The CSC200 will attempt ignition restart automatically after TC2 temperature falls below the TC2 setpoint temp, provided that all shutdowns are clear and no other issues are detected.
				(Default)	High Temperature Latch mode is On. The CSC200 will wait in High Temperature Latch mode and not attempt ignition restart until the On/Off switch, Remote On/Off terminal, or Modbus Remote Stop/Start is toggled Off, then On. " Ht " will flash on the display.
10	SD LATCH	Shutdown Latch			Shutdown Latch mode is Off. The CSC200 will attempt ignition restart automatically after the Shutdown and Level Shutdown have cleared, provided that all other On/Off or POC terminals are clear and no other issues are detected.
				(Default)	Shutdown Latch mode is On. The CSC200 will wait in Shutdown mode and not attempt ignition restart until the On/Off switch, Remote On/Off terminal, or Modbus Remote Stop/Start is toggled Off, then On. " Sd " will flash on the display.

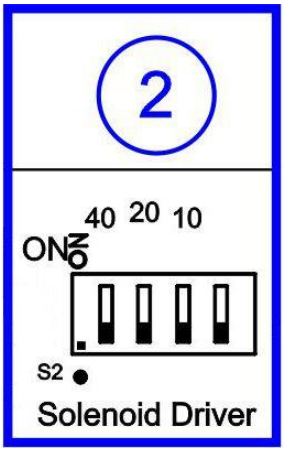
9	I/C PILOT	Intermittent / Continuous Pilot	(Default)		Intermittent Pilot Mode is selected when the DIP switch is set to "Off". The Pilot Solenoid output will turn on when the TC1 temperature is below the TC1 setpoint temp (the system is calling for heat). The Pilot Solenoid output will turn off when the TC1 temperature is above the TC1 setpoint temp.
					Continuous Pilot Mode is selected when the DIP switch is set to "On". As long as all shutdowns are clear, the Pilot Solenoid output will remain on regardless of whether the TC1 temperature is below the TC1 setpoint temp or above it.
8	PWR SAVE	Power Save	(Default)		Power Save mode is Off. The LED display will not be dimmed after 2 minutes of inactivity on the overlay buttons.
					Power Save mode is On. The LED display will be dimmed after 2 minutes of inactivity on the overlay buttons. TC1/2 select LEDs will also turn off but the ignition power LED will remain on if flame is present. Any buttons pushed will restore the display to full brightness again.
7	TC2 H/L	TC2 High / Low Range	(Default)		Thermocouple 2 High/Low range setting - High Range is selected: -60°C to 1100°C or -76°F to 2012°F **Firmware v3.9: Unused DIP switch**
					Thermocouple 2 High/Low range setting - Low Range is selected: 0°C to 500°C or -32°F to 932°F **Firmware v3.9: Unused DIP switch**
6	TC2 D/E	TC2 Disable / Enable			Thermocouple 2 (TC2) Disabled. Only Thermocouple 1 will be used for temperature shutdown.
				(Default)	Thermocouple 2 (TC2) Enabled for use (Default). Both Thermocouple 1 and 2 will be used. TC2 is usually used as a high temperature shutdown.
5	TC1 H/L **FW v3.9: IGN 0/3**	TC1 High / Low Range	(Default)		Thermocouple 1 High/Low range setting - High Range is selected: -60°C to 1100°C or -76°F to 2012°F **Firmware v3.9: goes to " FF " on display (flame fail) if ignition module loses flame detect after flame has been present. Requires a manual relight as this mode selects zero retries.**
					Thermocouple 1 High/Low range setting - Low Range is selected: 0°C to 500°C or -32°F to 932°F **Firmware v3.9: "rELt" (relight) shown on display if ignition module loses flame detect. IGN module will attempt a relight after 2 seconds and will try to relight up to 3 times with 15s purge time in between relight attempts**
4	BTN D/E	Buttons Disable / Enable			Up/Down Overlay Buttons are Disabled. This prevents the TC1 and TC2 setpoints from being changed via the overlay buttons once they're set to the desired setting.
				(Default)	Up/Down Overlay Buttons are Enabled (Default).

<table>
<tr><td>3</td><td>DBAND2</td><td>Deadband 2</td><td></td><td></td><td rowspan="4">Two DIP switches are used to select the desired deadband temperature range around the setpoint temp where the CSC200's decisions are made. A measured temperature would have to be above the setpoint temp before turning off the solenoids. To turn heat on again, the measured temp would need to be below the setpoint minus the deadband setting.

<table><tr><th colspan="2">DBAND2</th><th colspan="2">DBAND1</th><th>°C</th><th>°F</th></tr><tr><td>OFF</td><td></td><td>OFF</td><td></td><td>5</td><td>10</td></tr><tr><td>OFF</td><td></td><td>ON</td><td></td><td>3</td><td>6</td></tr><tr><td>ON</td><td></td><td>OFF</td><td></td><td>2</td><td>4</td></tr><tr><td>ON</td><td></td><td>ON</td><td></td><td>1</td><td>2</td></tr></table>
A larger deadband range prevents the igniter from turning on and off if the measured temperature hovers around the setpoint.</td></tr>
<tr><td></td><td></td><td></td><td></td><td>(Default)</td></tr>
<tr><td>2</td><td>DBAND1</td><td>Deadband 1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>(Default)</td></tr>
<tr><td>1</td><td>°C / °F</td><td>Temperature units display setting</td><td>(Default)</td><td></td><td>Display Temperature in degrees Celsius on the LED display</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Display Temperature in degrees Fahrenheit on the LED display</td></tr>
</table>

Low Power Solenoid (Solenoid Driver) DIP Switch (S2, 4-pin)

The Low Power Solenoid Drivers are individual control circuits added to each solenoid output that saves power drawn by the solenoid by altering the cycle time power is delivered to the solenoid once it is driven fully on. Larger solenoids require more power to keep them open, therefore needing a larger cycle time (eg: 40%).



The cycle time percentage is determined by adding the contribution of each DIP switch. For example, to drive the solenoids at 60% cycle time, turn on DIP switches marked "40" and "20". To drive the solenoids at 30% cycle time, turn on DIP switches marked "20" and "10". The lower the cycle time percentage, the higher power reduction will be. For example, a 10% cycle time results in the highest power reduction to the solenoid valves. A 70% cycle time results in the least power reduction to the solenoid valves.

For the Low Power Solenoid DIP switches, an "OFF" setting means the DIP switch is moved towards the "Solenoid Driver" text (to the bottom). An "ON" setting means the DIP switch is moved towards the "40", "20", or "10" text (towards the top).

DIP Switch Number	Name on Circuit Board	Description	OFF	ON	Operation
1	40	40% Low Power driver switch	(Default)		When DIP switch is off, the CSC200 does not add 40% to the cycle time sum for driving the solenoids.
					Adds 40% to the total cycle time sum.
2	20	20% Low Power driver switch	(Default)		When DIP switch is off, the CSC200 does not add 20% to the cycle time sum for driving the solenoids.
					Adds 20% to the total cycle time sum.

3	10	10% Low Power driver switch	 (Default)		When DIP switch is off, the CSC200 does not add 10% to the cycle time sum for driving the solenoids.
					Adds 10% to the total cycle time sum.
4	(blank)	Unused DIP switch **Firmware v3.9: Ignition Module Select**	 (Default)		**Firmware v3.9: Select this option when using a one-try ignition module (black label). DIP Switch "IGN 0 / 3" selects how many retry attempts after flame presence is lost.** **Regardless of DIP Switch "IGN 0 / 3" setting, initial attempt to light the pilot burner is done up to three times.**
					**Firmware v3.9: Select this option when using a three-try ignition module (white label).**

The following table summarizes firmware version 3.9 operation with different ignition modules and DIP switch settings:

	S2, 4-pin DIP Switch: DIP Switch 4		12-pin DIP Switch: "IGN 0 / 3" (or "TC1 H / L")			
Ignition Module Used	OFF (1-Try Select)	ON (3-Try Select)	OFF (IGN 0)	ON (IGN 3)	Condition	Operation
1-Try					Initial Start	Up to three tries performed to try to ignite pilot before FF, with a countdown between retries.
1-Try					Flame Presense Lost (FF)	Flame Fail, no retries to relight pilot attempted.
1-Try					Initial Start	Up to three tries performed to try to ignite pilot before FF, with a countdown between retries.
1-Try					Flame Presense Lost (FF)	Up to three tries performed to try to ignite pilot before FF, with a countdown between retries.
1-Try*					Initial Start	Only one try performed to try to ignite pilot before FF.
1-Try*					Flame Presense Lost (FF)	Flame Fail, no retries to relight pilot attempted.
1-Try*					Initial Start	Only one try performed to try to ignite pilot before FF.
1-Try*					Flame Presense Lost (FF)	Only one retry performed to try to ignite pilot before FF lockout. "rELt" briefly shown on display upon loss of flame.

3-Try*					Initial Start	Up to three tries performed to try to ignite pilot before FF. Countdown between retries done by ignition module.
3-Try*					Flame Presense Lost (FF)	One retry performed to try to ignite pilot before FF (should be zero but the 3-Try module performs an automatic retry to light).
3-Try*					Initial Start	Up to three tries performed to try to ignite pilot before FF. Countdown between retries done by ignition module.
3-Try*					Flame Presense Lost (FF)	Up to four tries performed to try to ignite pilot before FF, with a countdown between retries. "rELt" shown on display.
3-Try					Initial Start	Up to three tries performed to try to ignite pilot before FF. Countdown between retries done by ignition module.
3-Try					Flame Presense Lost (FF)	One retry performed to try to ignite pilot before FF (should be zero but the 3-Try module performs an automatic retry to light).
3-Try					Initial Start	Up to three tries performed to try to ignite pilot before FF. Countdown between retries done by ignition module.
3-Try					Flame Presense Lost (FF)	Up to three tries performed to try to ignite pilot before FF. Countdown between retries done by ignition module.

* - indicates incorrect setting(s) for the ignition module type installed

Connection Diagrams

The following diagrams show the wiring connections for the CSC200 Combustion Safety Controller.

Figure 5 - CSC200 Wiring Diagram Using Older Ignition Module

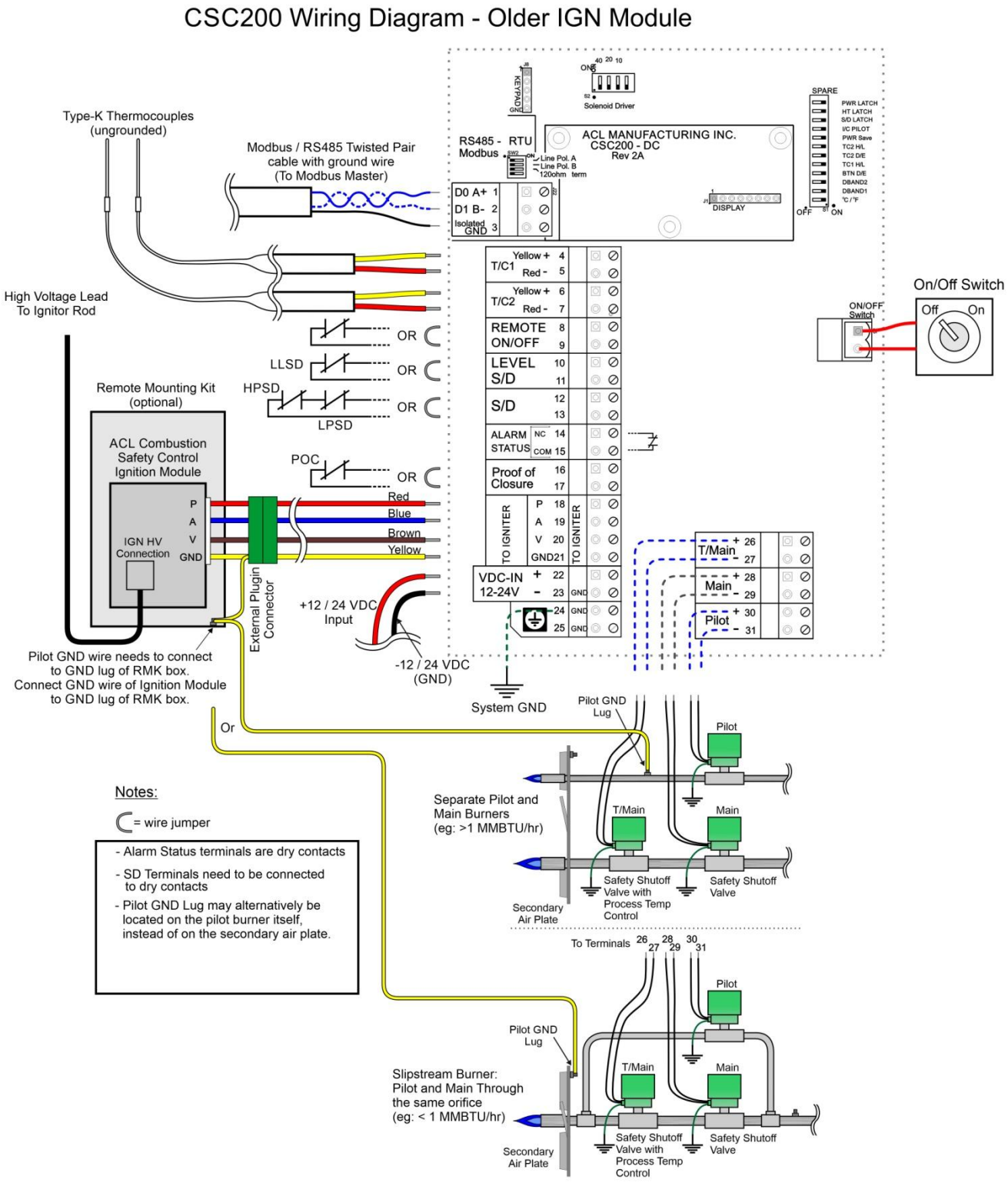
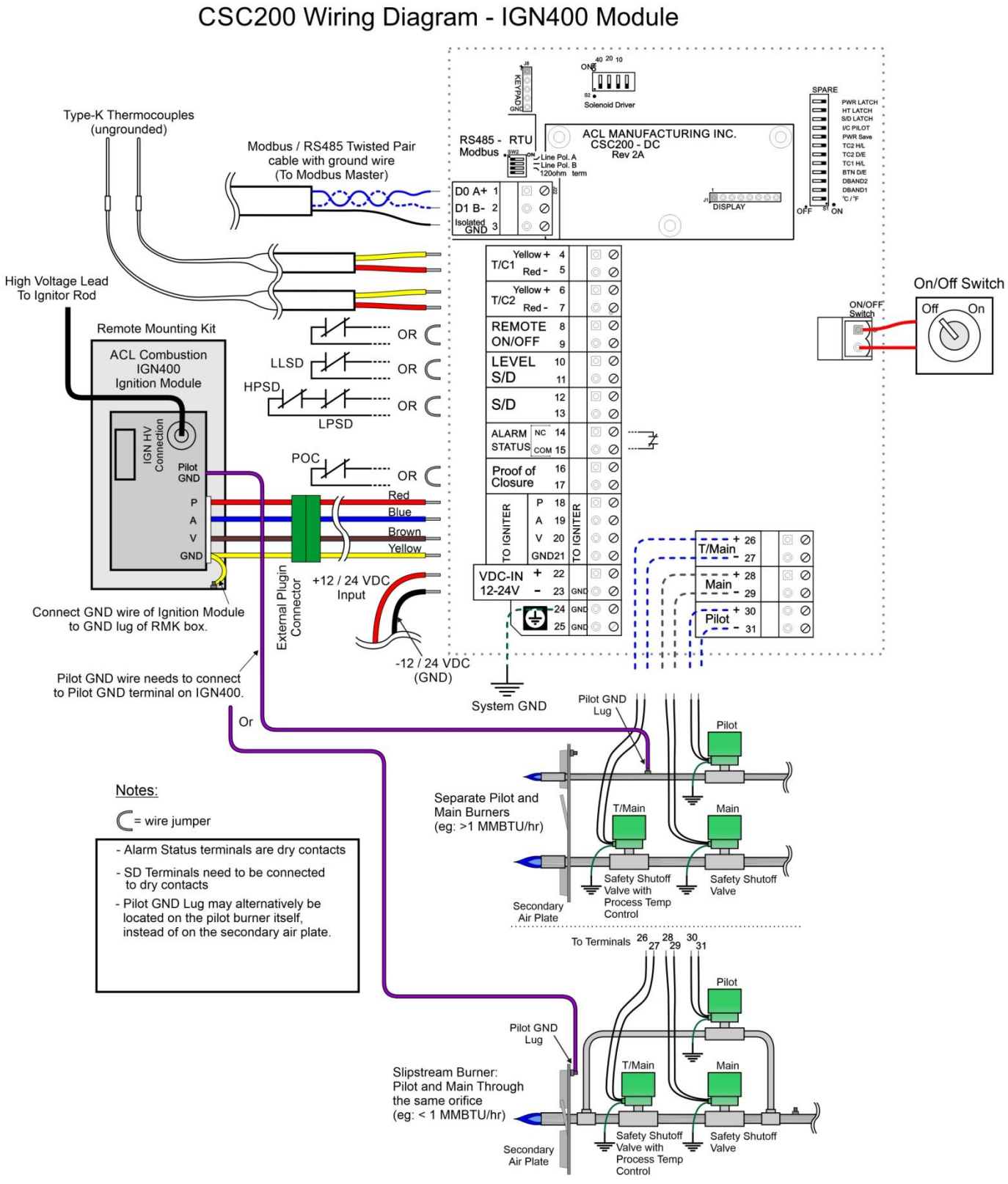


Figure 6 - CSC200 Wiring Diagram Using New IGN400 Ignition Module



Minimum Required Wiring Connections
Thermocouple 1
On/Off Switch (internal)
Ignition Module: P, A, V, GND
Main Input Power (+12/24VDC, -12/24VDC)
Pilot Solenoid Output
Main Solenoid Output (if a minimum of two valves are required)

Optional or Additional Functionality Connections
Thermocouple 2 (Set "TC2 D/E" DIP switch to Disabled if not used)
Remote On/Off (jumper if not used)
Level Shutdown (jumper if not used)
Shutdown (jumper if not used)
Alarm Status (dry contacts)
Proof of Closure (jumper if not used)
Main Solenoid Output (keep open/unconnected if not used)
T/Main Solenoid Output (keep open/unconnected if not used)

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.

Refer to the document "CSC200_Rev_2A_Modbus_Installation_Manual.pdf" for additional details on additional Modbus registers, testing, and troubleshooting.

Cabling

Connect a cable from a PLC (Programmable Logic Controller) or a PC to the 3-pin terminal strip of the CSC200 labeled "Modbus", observing proper connections:

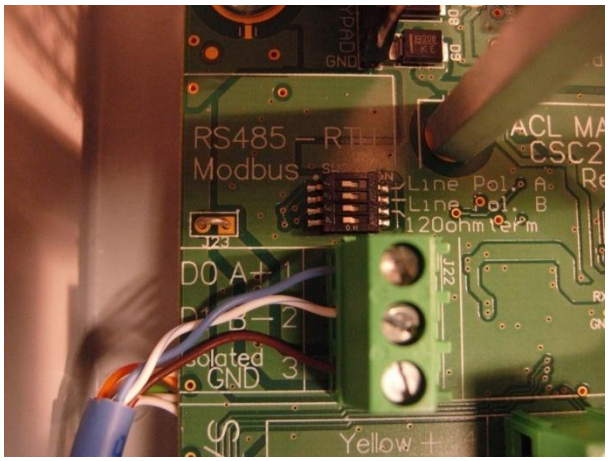
- The RS-485 standard suggests using twisted pair type cables (CAT5E or a shielded twisted pair with ground) for connecting devices together. This is definitely a requirement for longer cable runs (25m to 1000m) and for use in noisy environments like industrial or commercial installations.

- 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:

CSC200 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 7 - 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 CSC200, or at the master's ground terminal.

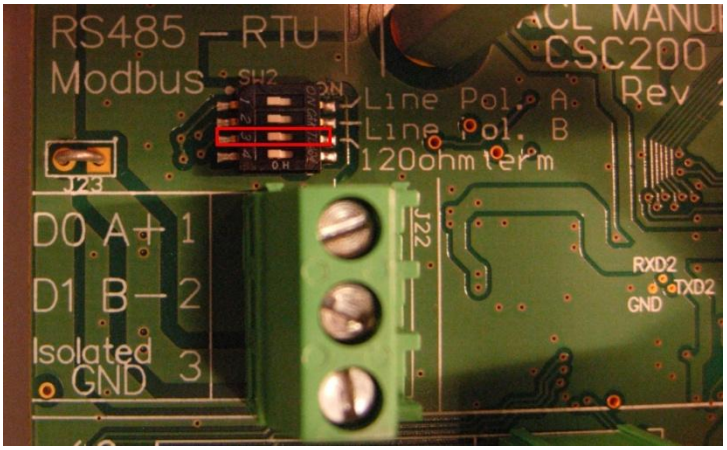
- A USB-to-RS485 cable may also have unused wires if the provided Terminator resistor wires are not used (the FTDI Chip cable as an example). These should be connected to ground as well, to reduce noise propagation.

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 CSC200 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 8 - 120 ohm Termination Resistor DIP Switch

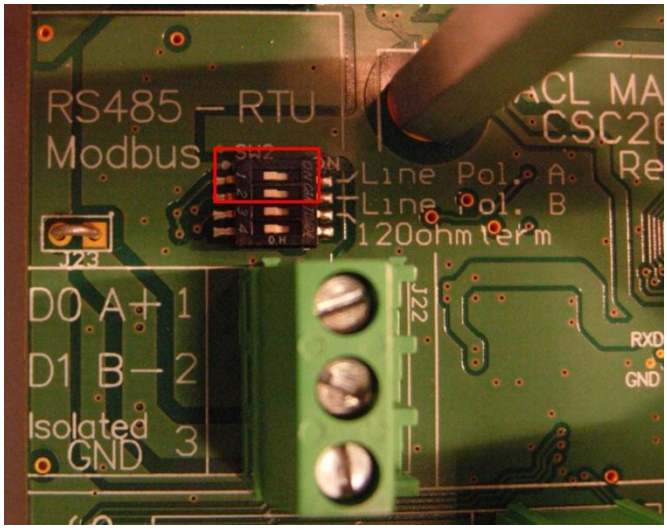


Line Polarization

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 CSC200 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. If the DIP switches are moved towards the left, the Line Polarization terminations are removed from the RS-485 bus on this CSC200 device.

Figure 9 – 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 CSC200 Controller is isolated from the onboard CSC200 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 CSC200 earth ground to shunt noise away locally instead of at the Modbus master. A solid ground connection should be made between a CSC200 earth ground terminal to an earth ground external to the CSC200 using a minimum 16AWG wire.

Commonly Used CSC200 Modbus Registers

Notes:

- SCADAPack Register Addresses are listed for reference when programming SCADAPack PLC units.
- See Appendix A - Full CSC200 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 one byte.

SCADAPack Register Address	Coil #	Modbus Coil Address	Description	Type	Notes
1	1	0	Reserved		
2	2	1	Reserved		
3	3	2	Pilot solenoid relay	Solenoid relay	
4	4	3	Main solenoid relay	Solenoid relay	
5	5	4	Alarm relay	Control relay	
6	6	5	Not used	N/A	Reserved
7	7	6	Proof of closure relay	Control relay	
8	8	7	Temperature Main solenoid relay	Solenoid relay	

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 Alarm input	1 = Alarm signal high (Alarm indicated)
10002	2	1	0	1	Igniter Valve input	1 = Valve signal high
10003	3	2	0	2	Main solenoid	1 = Main solenoid is on
10004	4	3	0	3	Pilot solenoid	1 = Pilot solenoid is on
10005	5	4	0	4	T/Main solenoid	1 = T/Main solenoid is on
10006	6	5	0	5	On/Off switch "minus" input	1 = On/Off switch is On (12VDC present), 0 = OFF
10007	7	6	0	6	POC relay output	1 = POC 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)	Shutdown input	1 = Shutdown input is High (12VDC present, shutdown sensor not tripped)
10010	10	9	1	1	Remote On/Off input	1 = Remote On/Off switch is On/Closed (12VDC present)
10011	11	10	1	2	HT input: On/Off switch "plus" 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 (only on briefly upon powerup)	
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)	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 (CSC200 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	Pilot Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10022	22	21	2	5	Main Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10023	23	22	2	6	TMain Solenoid Fault (Short)	1 = Solenoid fault (short), 0 = no fault
10024	24	23	2	7 (MSB)	TC1 calibration ratio error (out of acceptable range)	1 = an error was detected in the calibration ratio for TC1. A recalibration is needed
					DIP Switches, first byte	
10025	25	24	3	0 (LSB)	Power Fail Latch Select	1 = Power Fail Latch Select is ON
10026	26	25	3	1	High Temp Latch Select	1 = High Temp Latch Select is ON
10027	27	26	3	2	Shutdown Latch Select	0 = Shutdown Latch Select is ON
10028	28	27	3	3	Intermittent / Continuous Pilot Select	0 = Intermittent Pilot, 1 = Continuous Pilot Select
10029	29	28	3	4	Power Save	1 = Power Save ON (dim LED display after 2 min of no button adjustments)
10030	30	29	3	5	TC2 High / Low Range Select	1 = TC2 Low range select, 0 = TC2 High range select
10031	31	30	3	6	TC2 Disable / Enable	0 = TC2 Disable, 1 = Enable
10032	32	31	3	7 (MSB)	TC1 High / Low Range Select	1 = TC1 Low range select, 0 = TC1 High range select
					DIP Switches, second byte	
10033	33	32	4	0 (LSB)	Button Disable / Enable	
10034	34	33	4	1	Deadband 2	DB2,DB1 = 0,0 --> 5 deg C, 10 deg F

10035	35	34	4	2	Deadband 1	DB2,DB1 = 0,1 --> 3 deg C, 6 deg F
						DB2,DB1 = 1,0 --> 2 deg C, 4 deg F
						DB2,DB1 = 1,1 --> 1 deg C, 2 deg F
10036	36	35	4	3	Deg C / Deg F	0 = Display Temp in Deg C, 1 = Display Temp in Deg F
10037	37	36	4	4	Low Power Solenoid: 40%	1 = OFF, 0 = LP sol mode ON, solenoid driven at 40% (power driving solenoid is the sum of percentages turned ON, eg: 40% and 10% ON = solenoid driven at 50%)
10038	38	37	4	5	Low Power Solenoid: 20%	1 = OFF, 0 = LP sol mode ON, solenoid driven at 20% (power driving solenoid is the sum of percentages turned ON, eg: 20% and 10% ON = solenoid driven at 30%)
10039	39	38	4	6	Low Power Solenoid: 10%	1 = OFF, 0 = LP sol mode ON, solenoid driven at 10%
10040	40	39	4	7 (MSB)	TC2 calibration ratio error (out of acceptable range)	1 = an error was detected in the calibration ratio for TC2. A recalibration is needed

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)	
40002	2	1	TC2 temp setpoint (deg C)	
40003	3	2	TC1 temp setpoint (deg F)	
40004	4	3	TC2 temp setpoint (deg F)	

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)	
30002	2	1	TC2 current temp (deg C)	
30003	3	2	TC1 current temp (deg F)	
30004	4	3	TC2 current temp (deg F)	

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 CSC200. CSC200 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	Type	Notes
9	9	8	Increment TC1 setpoint		ON = increment TC1 setpoint, OFF = no effect
10	10	9	Decrement TC1 setpoint		ON = increment TC1 setpoint, OFF = no effect
11	11	10	Increment TC2 setpoint		ON = increment TC1 setpoint, OFF = no effect
12	12	11	Decrement TC2 setpoint		ON = increment TC1 setpoint, OFF = no effect
13	13	12	Remote Stop		ON = Stop, OFF = no effect
14	14	13	Remote Start		ON = Start, 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 On/Off power rung
- Remote Stop can also be cleared by receiving a Modbus message turning Remote Start ON
- Remote Start enables the CSC200 to be turned on
- Remote Start can be interrupted if ON/OFF switch is OFF, if Remote On/Off 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

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)	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)	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)	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)	Writing a value to TC2 in degrees F, also writes to the TC2 degrees C register (after conversion)
40005	5	4	Unlock Slave ID register	Write a "0x55AA" (21930) to this register to unlock the Slave ID for changing
40006	6	5	Slave ID register	Write the new Slave ID value to use for this CSC200 unit to this register once it's been "unlocked" using the previous register (register address 4)
				(ID change is made after the response is sent)
				(Unlock Slave ID register (reg # 5, address 4) is also reset to zero after the Slave ID is changed)

Appendix A - Applicable Standard and Code Requirements

CSA Standard C22.2 No. 0-10 - General Requirements-Canadian Electrical Code Part II

CAN/CSA-C22.2 No. 0.4-04 - Bonding of Electrical Equipment

CSA Standard C22.2 No. 94-M91 - Special Purpose Enclosures

CSA Standard C22.2 No. 142-M1987 - Process Control Equipment

CSA C22.2 No. 199-M89 - Combustion Safety Controls and Solid-State Ignitors for Gas and Oil Burning Equipment

CSA Standard C22.2 No. 213-M1987 - Non-Incendive Electrical Equipment for Use in Class I, Division 2 Hazardous Locations

UL Standard 50, 12th Edition - Industrial Control Equipment for Use in Hazardous (Classified) Locations

UL746C, 6th Edition - Standard for Polymeric Materials - Use in Electrical Equipment Evaluations

UL 508, 17th Edition - Industrial Control Equipment

ANSI/UL 698 13th Edition - Industrial Control Equipment for use in Hazardous (Classified) Locations

ANSI Z21.20-2005 - Automatic Gas Ignition Systems and Components

ANSI ISA 12.12.01-2007- Non Incendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations

Appendix B - CSC200 Rev 2A Technical Specifications

General Notes:

- All components on the CSC200 Controller are RoHS compliant.

Modbus 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 on the top of the CSC200 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 (Electrostatic Discharge) events up to +/- 15kV (Air-Gap and Human Body Model) and up to +/- 8kV Contact Discharge (IEC61000-4-2).

Specification	**Default Value**	**Possible Values or Range**
Modbus Protocol	Modbus RTU	Modbus RTU
Modbus Slave ID (address)	2	1 - 247
Modbus/RS-485 Serial Settings:		
Baud rate	9600	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 (Modbus) 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		96k ohms 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)

Inputs and Control Outputs:		
Main Power Input, Voltage Range		10VDC (minimum) to 29VDC (maximum)
System Current Draw, no solenoid outputs on		300mA Max, 100 mA typical (at 12VDC)
System Current Draw, Pilot solenoid output on, no Low Power solenoid drivers engaged		
Solenoid Outputs:		
Voltage Output on Solenoid terminals (12VDC main input)		Main Power Input minus a small voltage drop that is dependent on current draw and temperature: Solenoid outputs are 11.8V to 11.98V (approx.)
Voltage Output on Solenoid terminals (24VDC main input)		Main Power Input minus a small voltage drop that is dependent on current draw and temperature: Solenoid outputs are 23.8V to 23.98V (approx.)
Voltage Output on Solenoid terminals (10VDC main input)		Main Power Input minus a small voltage drop that is dependent on current draw and temperature: Solenoid outputs are 9.8V to 9.98V (approx.)
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 and Special Key Sequences

> Refer to the document "CSC200_Rev_2A_Modbus_Installation_Manual.pdf" for additional details on additional Modbus registers, programming, testing, and troubleshooting.

Additional Modbus documentation is 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:

CSC200 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 CSC200 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 CSC200 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 CSC200 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 CSC200 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 CSC200 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 CSC200 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 CSC200 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 CSC200 Controller can operate at a maximum rate of 115kbps but the maximum setting allowed in the CSC200 firmware is 38.4kbps (38400 baud, or raw bits per second).

Isolated (or Common) Ground

The "Isolated Ground" terminal on each CSC200 Controller is isolated from the onboard CSC200 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, the Isolated GND terminal is connected to the CSC200 earth ground to shunt noise away locally instead of at the Modbus master. This is done using a wire jumper soldered onto the main CSC200 circuit board at jumper J23, to the left of the three Modbus terminals and Modbus DIP switch.

A solid ground connection should be made between a CSC200 earth ground terminal to an earth ground external to the CSC200 using a minimum 16AWG wire.

Key Sequence To Reset Serial Settings to Default (9600 Baud, 8N1)

To reset the CSC200's serial settings to default, press and hold in the "1/2" button and the "Up" arrow button for longer than 10 seconds, but less than 15 seconds. Once the CSC200 has registered this button sequence, it will display the following on the display: "1nb" for 2 seconds, then "SEr", then "Sett", then "rSt".

To verify the serial settings have been reset to 9600 baud and 8 bits, No parity bits, and 1 stop bit ("8n1"), power off the CSC200, wait 5 seconds, then power it on again. The powerup sequence will show "PrF" (power fail), then the installed firmware version (e.g. "[3.7]"), then the current modbus Slave ID value ("2" by default), then "9600", then "8n1".

Key Sequence To Reset Serial Settings and The Modbus Slave ID to Default

To reset the CSC200's serial settings and Modbus slave ID to default, press and hold in the "1/2" button and the "Up" arrow button for longer than 15 seconds. Once the CSC200 has registered this button sequence, it will display the following on the display: "1nb" for 2 seconds, then "id", then "rSt".

To verify the Modbus Slave ID has been reset to "2", power off the CSC200, wait 5 seconds, then power it on again. The powerup sequence will show "PrF" (power fail), then the installed firmware version (e.g. "[3.7]"), then the current modbus Slave ID value (should be "2" as the default), then "9600" for the baud rate, then "8n1" as the serial settings (as an example).

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

The default Modbus Slave ID for a new CSC200 is "2".

Summary

#	Command to Perform (Modbus Function Code)	SCADAPack Register Address	Register Number	Modbus Holding Register Address	Register Description	Value to Write
1	Write Single Holding Register	40005	5	4	Unlock Slave ID register	0x55AA (21930)
2	Write Single Holding Register	40006	6	5	Slave ID register	New Desired Slave ID (0x0001 to 0x00F7)

Procedure When Using a PC Master to Change the Modbus Slave ID (Address)

1) Connect one end of a USB to RS-485 cable to the three screw terminals of the CSC200 Controller (refer to Appendix D for details if necessary). Connect the USB end to a PC. This CSC200 should be the only device attached to the RS-485 bus while changing the Slave ID (address) to avoid potential conflicts.

2) Run the desired Modbus Master software (examples are Modnet for Modbus or Modbus Constructor) and connect to the COM port used by the USB-to-RS485 cable. Default serial settings for the CSC200 are 9600 baud, 8N1, Modbus RTU.

3) Select the unique Slave ID for the CSC200 to communicate to (default Slave ID for a new CSC200 is "2"). Issue a Write Single Holding Register command to Modbus Holding Register Address 4 ("Unlock Slave ID register") using the value 0x55AA (21930). This command unlocks the Slave ID for changing it. This is used as a safety precaution to prevent inadvertent Slave ID changing.

Command to Write	Modbus Function Code	Write Address	Value to write
Write Single Holding Register	0x06	4 ("Unlock Slave ID register")	0x55AA (21930)

4) Issue a Write Single Holding Register command to Modbus Holding Register Address 5 ("Slave ID register") using the new desired Modbus Slave ID (address) that you want to assign to this CSC200. Values between 0x0001 and 0x00F7 are allowed. Note that the Modbus specification says that at least 32 Modbus devices can reside on one RS-485 bus (without repeaters). Testing needs to be done by the installer to ensure adequate signal integrity if more than 32 devices are placed on one Modbus RS-485 bus.

Command to Write	Modbus Function Code	Write Address	Value to write
Write Single Holding Register	0x06	5 ("Slave ID register")	Desired Modbus address value between 0x0001 and 0x00F7 (between 1 and 247)

Appendix E - Troubleshooting

Burner Management Troubleshooting

#	Issue	Possible Reason	Corrective Action
1	Fails to attempt ignition	Blown fuse	Check if the display is on or not: one of the TC1 or TC2 green LEDs should always be lit unless it's in Power Save mode. If Display is off, replace fuse with a 6.3A max fuse
		Supply voltage too low	Ensure that the minimum input voltage is 11.5VDC (measured with a volt meter) for use with 2-3 solenoid outputs
		Poor power connections	Check all connections on the terminal strips. Ensure that there are no short circuits, that the wires are tightly gripped inside the terminals, and that the screws on each terminal are tight.
		POC terminal not closed, display showing "POC"	Ensure that 12VDC is measured on both the POC+ and POC- terminals
2	Attempts ignition but pilot doesn't light	Fuel gas supply to Pilot may be too high or too low	Pilot fuel gas supply should be set at 5 pounds
		Gap setting on ignitor/flame rod not correct	Gap should be approximately 1/8" (3.175mm) and rod tip needs to be cut to a sharp point
		Ignition cable defective or insulation worn	Check continuity through the ignition cable. Multimeter should read close to zero ohms. If not, cable needs to be replaced.
		Poor ground connection	Ensure that good, thick ground connections are made at the CSC200 and at the Pilot/burner valve. The pilot burner (if a separate pilot is used) or main burner (if a slipstream burner with pilot & main together) ground lug wiring should connect back to the ignition module wiring harness ground. Check this connection.
		Pilot solenoid failure	Check supply power to solenoid. Check gas flow through solenoid
		Plugged orifice on Pilot	Clean out Pilot orifice (Do Not redrill!)
3	Weak or Erratic Spark	Gap setting too wide or rod not cut to a point	Shorten gap setting to approximately 1/8" (3.175mm) and recut the ignitor rod tip
		Ignition cable defective or insulation worn	Check continuity through the ignition cable. Multimeter should read close to zero ohms. If not, cable needs to be replaced.
		Poor ground connection	Ensure that good, thick ground connections are made at the CSC200 and at the ignitor tip
		Contaminated ignitor rod or Pilot nozzle	Remove Pilot assembly, clean rod and nozzle, and reinstall
4	Solenoid valve not opening	No power to solenoid valve or faulty solenoid valve	Replace defective solenoid valve
5	Solenoid valve opens but then closes again (intermittent operation)	Wrong Low Power Solenoid Driver setting for the attached solenoids	Verify that the Low Power Solenoid Driver DIP switch settings are matched to the solenoid valves connected to the CSC200.

		Voltage droop on input	Some larger solenoid valves rated for 12VDC require an output voltage very near to 12VDC. Measure the output voltage on the solenoid terminals to ensure that it's sufficient (approx. >= 11.5VDC). Higher current drawn on each solenoid output will cause slightly higher voltage drops which may interfere with solenoid operation. Input voltage may need to be boosted to 12.5VDC if multiple large solenoids are attached to one solenoid output.
6	CSC200 keeps rebooting/resetting when trying to start	Short circuit on a shutdown or in wiring to ignition module	Refer to the Ignition Module Power Flow diagram on page 7 for diagnosing where the short may be. Remove wires / jumpers from each set of terminals starting at the ignition module to see where the controller stops resetting. For example, if you remove the wires from the Shutdown terminals after removing wires/jumpers from the POC and IGN module and it stops resetting when you turn on the On/Off switch, the issue is either in the shutdown wiring or on the CSC200 main board itself. Sometimes transient voltage suppressing diodes (TVS or transorbs) fail to a short during a large noise spike (eg: during a lightning storm).
7	Pilot flame is confirmed but goes into Flame Fail when Main solenoid valve opens	Main flame is possibly turning on too fast.	Needle/speed valve on Kimray valve may have been adjusted for the Kimray valve to open too fast. Only 1/4 to 1/2 turn is usually needed (as an initial test) on the speed valve screw. Once opened, the Main burner should gradually increase flow to full over 10-15 seconds.
8	CSC200 shuts down continually on High Temp	- Small fire tube - Strong pilot - TC location too close to fire tube - Leaking solenoid - TC2 (high temp) setpoint too close to TC1 setpoint	Check the easiest first: check if pilot pressure is too high, check if TC2 setpoint is too close to TC1 setpoint (5-20F is quite tight), check if flame is still present if CSC200 is turning off (may be leaky valve).

Modbus Communication Troubleshooting

#	Issue	Possible Reason	Corrective Action
1	Modbus Master can't read temperature values from CSC200 (or any other data)	RS485 cable isn't connected properly	Ensure the wires for the RS485 cable are connected properly at the CSC200 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 CSC200	Verify that the address used by the master to communicate with the CSC200 matches the address set in the CSC200. 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 CSC200 may have been interrupted	Verify the CSC200 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 CSC200 and an appropriate earth ground external to the CSC200 (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 CSC200 Controller to the CSC200 earth ground terminal to provide a localized ground path for noise. (Attach GND jumper on Rev 2B cards and later)
		Power to the CSC200 may have been interrupted	Verify the CSC200 has power locally.
3	Modbus PC Master communication with CSC200 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 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.
			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 CSC200 may have been interrupted	Verify the CSC200 has power locally.
4	Modbus communication works for writing Remote Stop, Remote Start, but no values are being read back	CSC200's ignition module may be "sparking".	The CSC200 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:

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