Amanda Hoebel
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Boiler.vi

Abstract: This VI simulates a series of startup controls for a Boiler.

Details: This VI simulates the controls for operating a boiler. A queued state machine is implemented. An enumerated type is connected to an Obtain Queue function to start the queue. An Enqueue Element is used to load the Initialize state into the queue, and passes the information to the Dequeue Element function inside of a while loop. The Dequeue Element implements the queued element in the selector frame. The first element will be the Initialize state. A separate while loop allows the user to turn off the VI at any point in the sequence. This is done by a Value Change frame based on the stop button, enclosed in a while loop. If the value of the stop button changes, the sequence frame End is passed through the queue to the second while loop, sending the second loop to the End frame and stopping the while loop.

The VI moves to the Initialize frame, setting the Boiler Controls, Boiler Simulation Controls, and Boiler Status Indicator LEDs to false, with the status "Lockout" displayed in the Boiler Status Indicators. The Pilot light is set to non-blinking, in the event that the user stopped the program on the Pre-Purge sequence, which causes the Pilot light to blink. A header for the Timestamp, Event, and Event Data is printed to a csv text file labeled "Boiler Log.txt" (located in the same directory as the VI), followed by the status "Boiler Initialized" and the absolute date and time (timestamp). The VI moves to the Boiler Reset frame.

The VI stays on the Boiler Reset frame until the user toggles on both the Run Interlock switch and the Boiler Reset button. When both values are true, the Boiler Status Indicators cluster reads "Ready", followed by all LED indicators set to false. The Boiler Reset button is automatically toggled back to the off position. The status "Boiler Ready" and the timestamp are recorded in the log file. The VI moves to the Reset Lockout frame.

The VI stays on the Reset Lockout frame until the user toggles the Start Sequence button on the Boiler Controls cluster to true. The VI moves to the Pre-Purge frame.

The pre-purge loop is activated, reading "Pre-Purge" in the Boiler Status Indicators and the Primary Fan LED set to true. The passing time (in seconds) is shown in the Time Count indicator. The status "Start Pre-Purge", timestamp, and the passed time (in seconds) are printed in the log file. The timer runs for ten seconds. The Pilot sequence is placed in the queue as the next frame to go to after the pre-purge finishes, placed in a flat sequence frame before the timed loop. This is so that if the user selects the stop button before the pre-purge loop has finished, the Stop sequence command will be next in the queue instead of the Pilot sequence and will stop the program after the loop finishes. When the loop finishes, the Boiler Status Indicators reads 0 for the Time Count indicator, "Pre-Purge Complete" for the string, sets the Primary Fan LED to false, and turns the Pilot LED to true. A property node sets the Pilot LED to blink. The timestamp, "Pre-Purge Complete" string, and elapsed time (in seconds) is printed to the log file. The VI continues to whichever frame is next in the queue (the Pilot frame, if the stop button was not selected).

The VI stays on the Pilot frame until the user toggles the Pilot button in the Boiler Controls cluster to true. The string "Pilot On" is printed in the Boiler Status Indicators. The Natural Gas Valve and the Pilot indicators are both set to true, with the blinking for the Pilot LED set to false. The status "Pilot On", along with the timestamp and the string "True" are written to the log file. The VI moves to the Ignition frame.

The VI stays on the Ignition frame until the Flame Sensor Value (%) is greater than 30%. When this condition is true, the Pilot LED is set to false and the Natural Gas Valve and Fuel Valve are set to true. The status "Pilot Proved", timestamp, and Flame Sensor Value (%) value are written to the log file. The VI moves to the Forced Draft Fan frame.

The VI stays on the Forced Draft Fan frame until the user sets the Forced Draft Fan switch in the Boiler Simulation Controls to true. The status "Forced Draft Fan On", timestamp, and string "True" are written to the log file. The VI moves to the Run frame.

The VI stays on the Run frame until the Fuel Valve Position is greater than 10 % open. When this condition is met, the Boiler Status Indicators show "Boiler Running" as the status, and all LEDs except for Fuel Valve are false. The status "Boiler Running", timestamp, and the Fuel Valv Position value are written to the log file. The VI moves to the Interlock frame.

The VI stays on the Interlock frame until a condition is met that causes a Purge of the system. The conditions that cause a purge are: Run Interlock switch toggled to false, Forced Draft Fan switch toggled to false, Shutdown button toggled to true, and Fuel Valve Position greater than 75 % or less than 10 % open. If any of these conditions are true, the VI moves to the Shutdown frame.

The purge loop is activated, reading "Purge" in the Boiler Status Indicators. The Primary Fan LED is set to true and all other LEDs are set to false. The passing time (in seconds) is shown in the Time Count indicator. The status "Start Shutdown Purge", timestamp, and the passed time (in seconds) are printed in the log file. The timer runs for ten seconds. Then, the Boiler Status Indicators reads "Lockout", and all LEDs are set to false. The Time Count indicator resets to 0. The status "Shutdown Purge Complete", timestamp, and the elapsed time (in seconds) are printed to the log file. The VI moves to the End frame.

The End Frame sets the stop value to true and turns off the while loop. The Value Change frame in the first while loopp will continue to run until the user selects the stop button. When the stop button is selected, the stop button for the while loop around the value change frame will be set to true and the queue will be passed to a Release Queue function. The queue is released and the VI stops.

Inputs: There are three inputs.
Cluster labeled "Boiler Controls": Cluster containing "Boiler Reset" button (BOOL), "Start Sequence" button (BOOL), "Pilot" button (BOOL), "Shutdown" button (BOOL), and a "Fuel Control Valve Position" knob (DBL) used to simulate a startup procedure for resetting the boiler, starting the boiler sequence, turning on the pilot, and shutting down the boiler. The knob is used to simulate the percent in which the fuel valve is open.
Cluster labeled "Boiler Simulation Controls": Cluster containing "Run Interlock" switch (BOOL), "Forced Draft Fan" switch (BOOL), and "Flame Sensor Value (%)" slider (DBL). The Run Interlock and Forced Draft Fan switches are conditions that must be set to true (toggled on) in order to progress the boiler sequence. The Flame Sensor Value slider is used to simulate the percent flame for the pilot, in order to turn on the boiler.
Square button (BOOL) labeled "Stop": Used to stop the while loop iterations. The default value is set to "True" in order to keep the while loop running until the stop button is pressed. The Mechanical Action is set to"Latched When Released".

Outputs: There is one output.
Cluster labeled "Boiler Status Indicators": Cluster containing "Status" readout (STRING), "Primary Fan" indicator (BOOL), "Natural Gas Valve" indicator (BOOL), "Pilot" indicator (BOOL), "Fuel Valve" indicator (BOOL), "Forced Draft Fan" indicator (BOOL), and "Time Count" readout (DBL). The Status readout displays the status of the boiler though the sequence of controls. The five boolean indicators display what is activated during the sequence of controls. The Time Count readout reads the time (in seconds) for certain actions to occur.

Boiler Controls

Boiler Reset

RESET

Start Sequence

Start Sequence

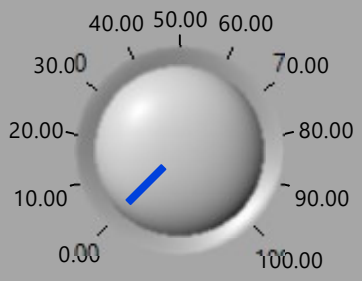
Pilot

Pilot

Shutdown

Shutdown

Fuel Control Valve Position (% Open)



Boiler Status Indicators

Status Lockout

Primary Fan

Natural Gas Valve

Pilot

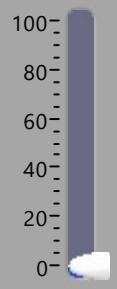
Fuel Valve

Forced Draft Fan

Time Count 0.00

Boiler Simulation Controls

Flame Sensor Value (%)



Run Interlock

Closed

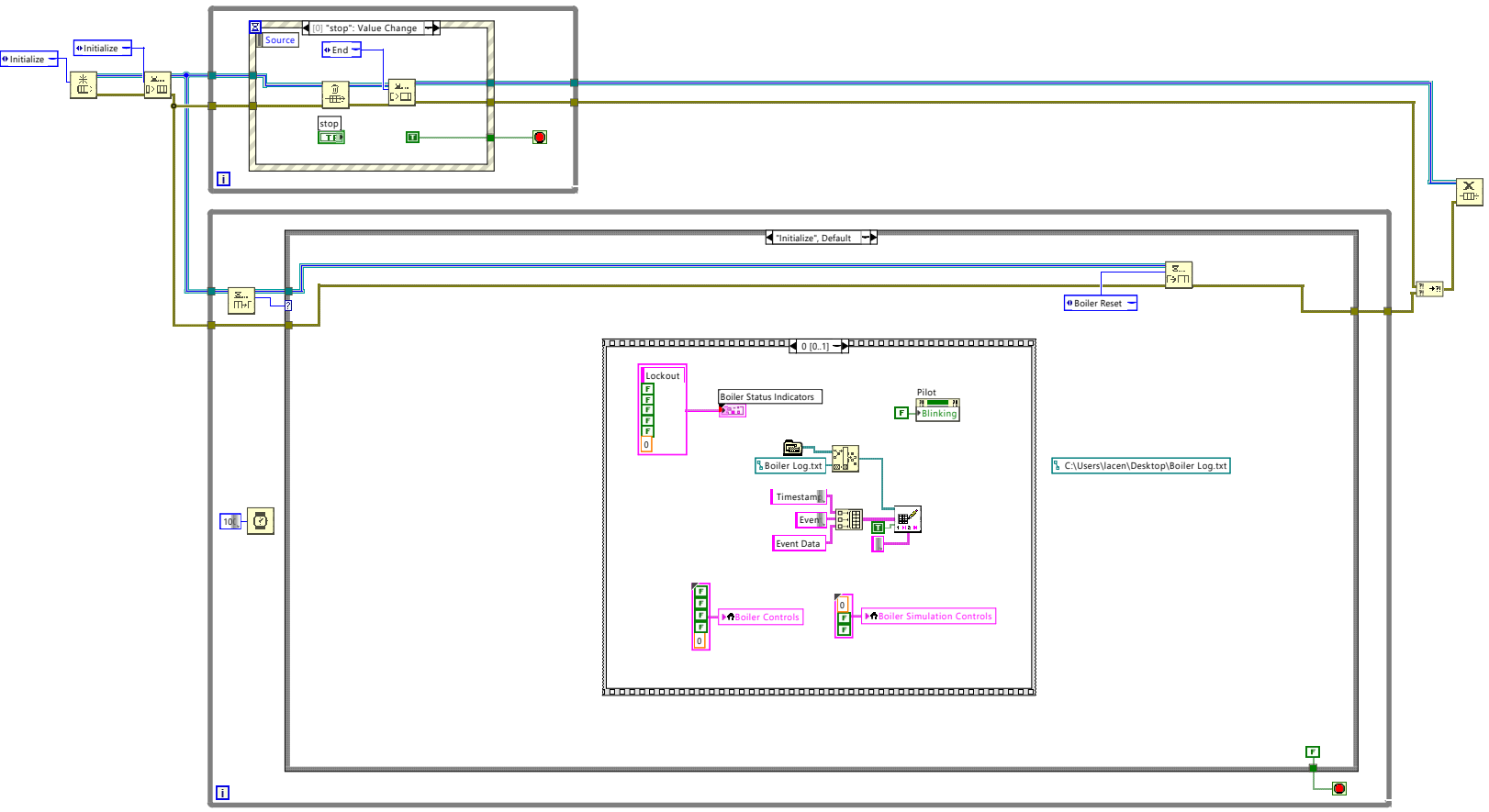
Open

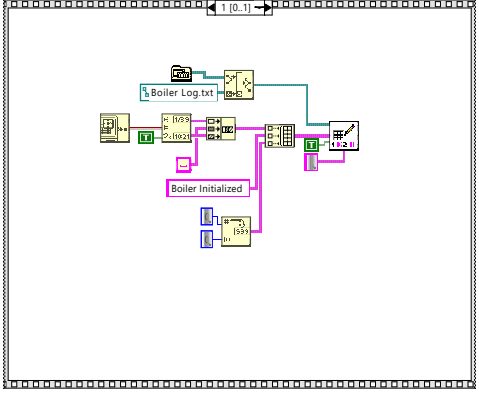
Forced Draft Fan

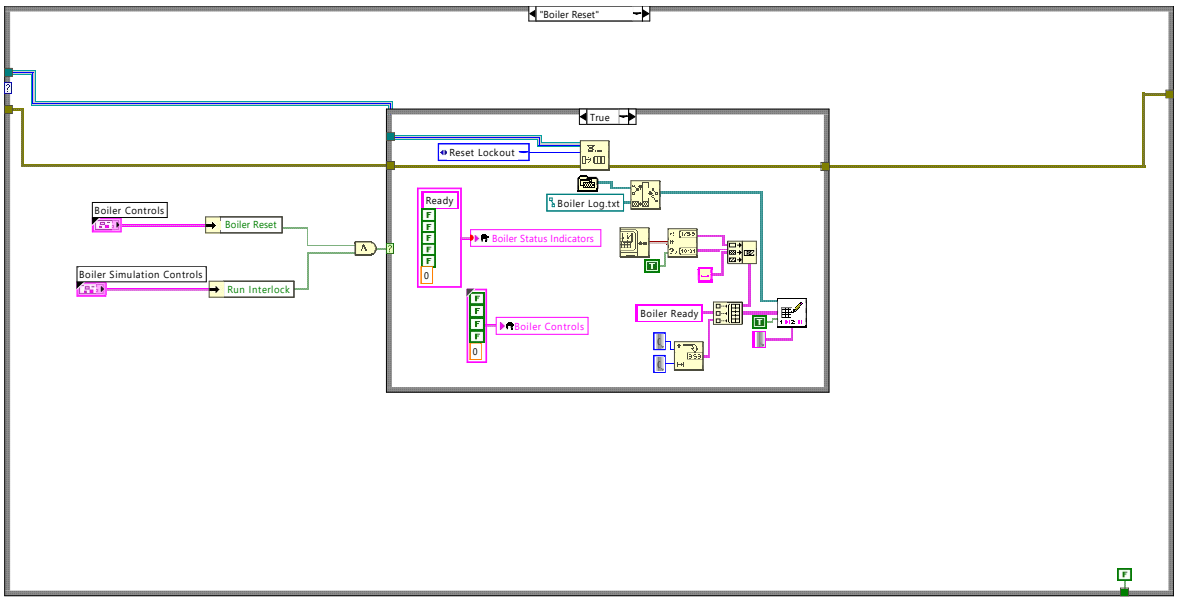
On

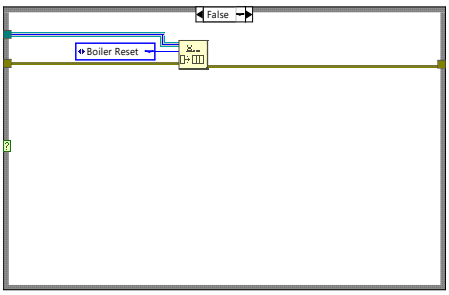
Off

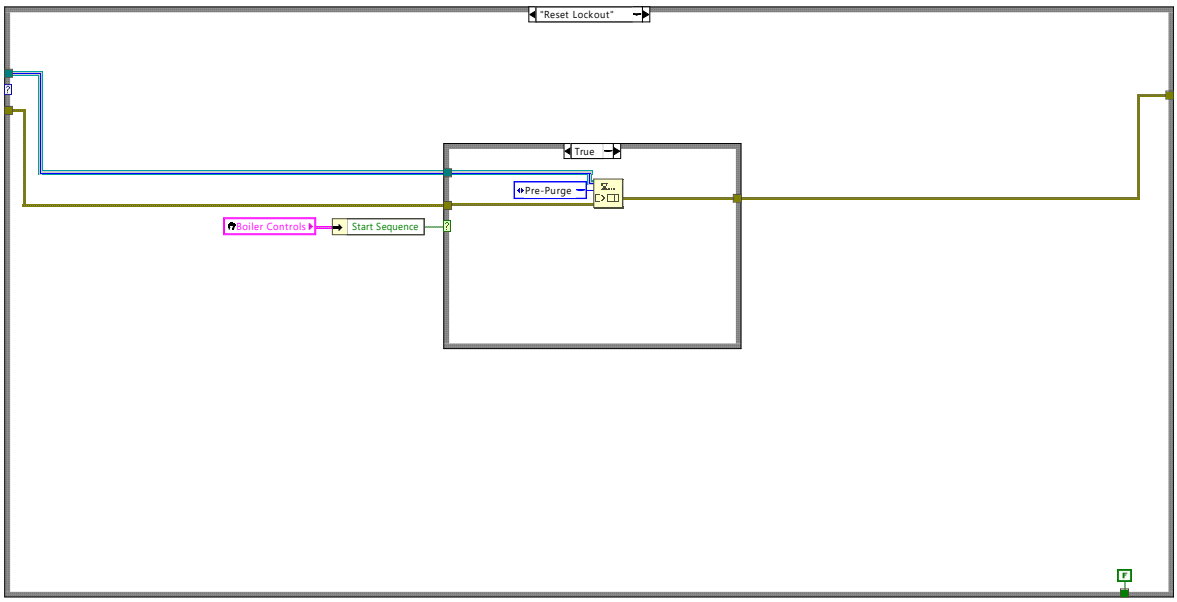
STOP

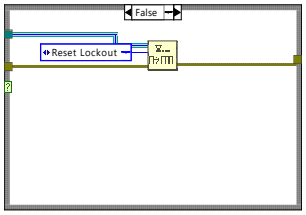


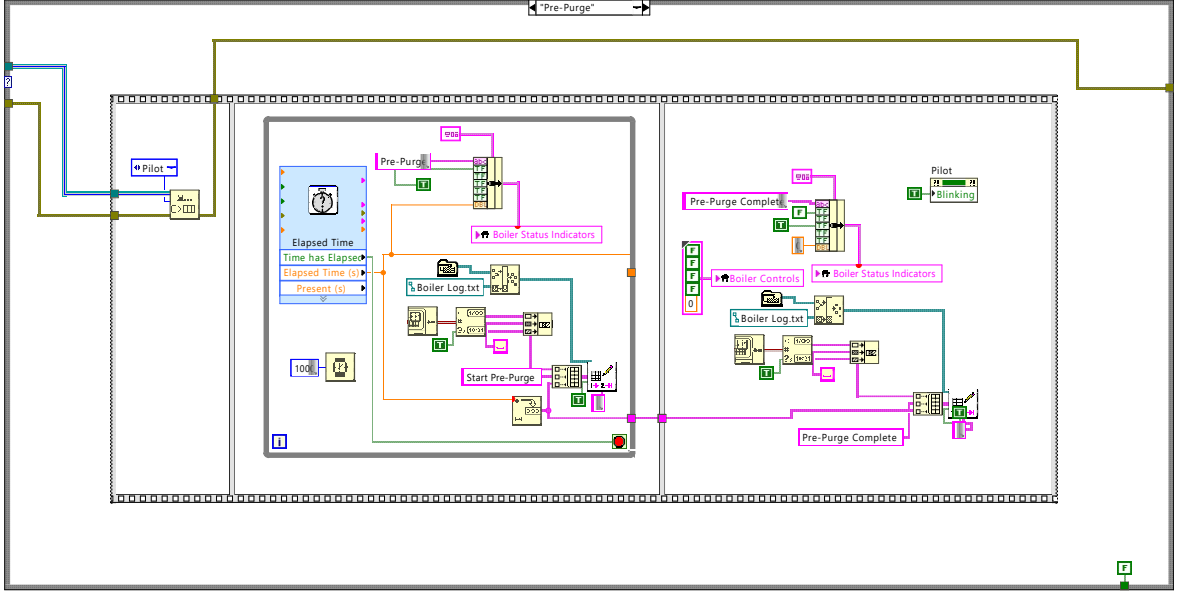

1 [0..1]
Boiler Log.txt
Boiler Initialized

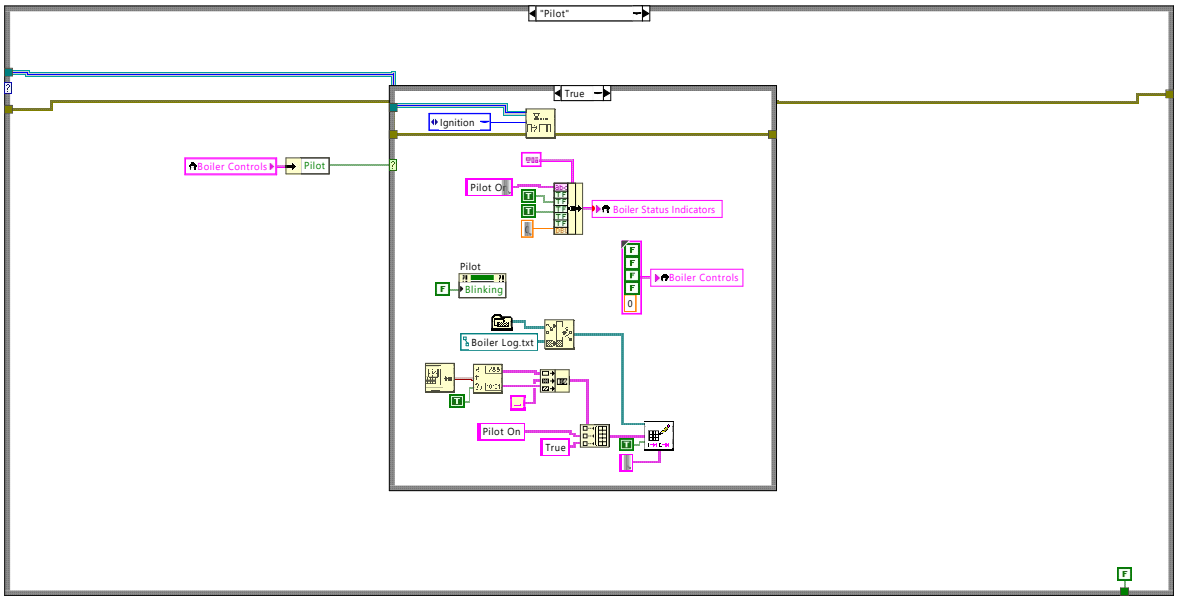

"Boiler Reset"
True
Reset Lockout
Boiler Controls
Boiler Reset
Boiler Simulation Controls
Run Interlock
Ready
Boiler Log.txt
Boiler Status Indicators
Boiler Controls
Boiler Ready

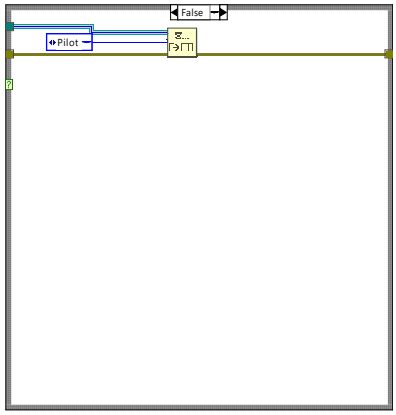

False
Boiler Reset

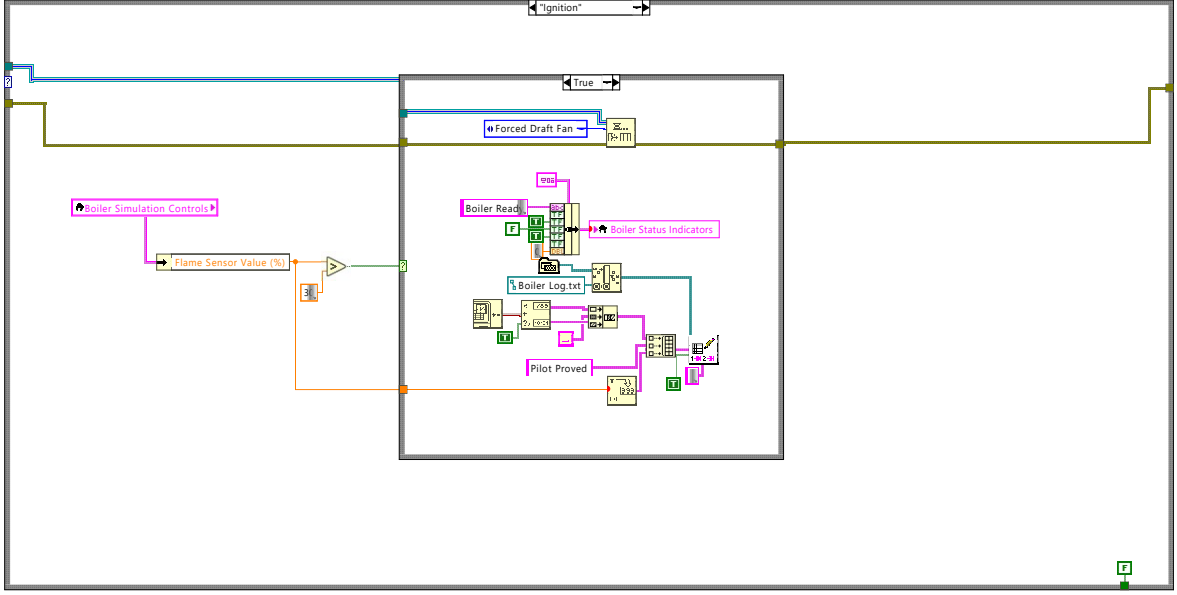

"Reset Lockout"
True
Pre-Purge
Boiler Controls
Start Sequence

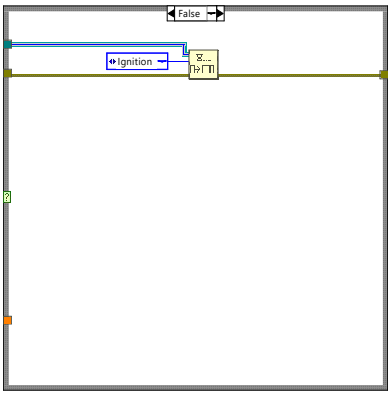

False
Reset Lockout

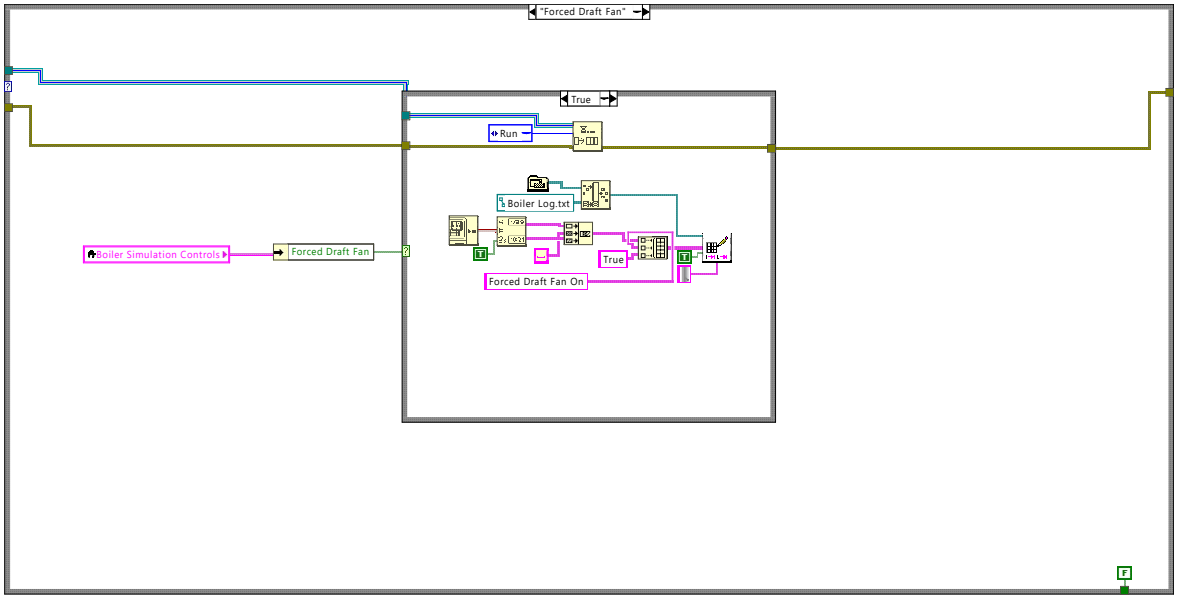

"Pre-Purge"
Pilot
Elapsed Time
Time has Elapsed
Elapsed Time (s)
Present (s)
100
Pre-Purge
Boiler Status Indicators
Boiler Log.txt
Start Pre-Purge
Pre-Purge Complete
Boiler Controls
Pilot
Blinking

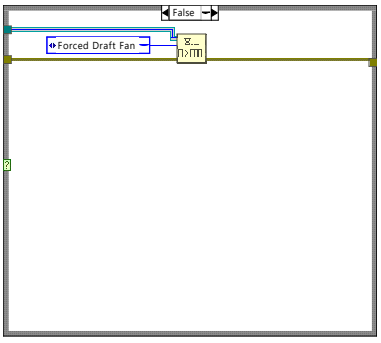

"Pilot"
True
Ignition
Boiler Controls
Pilot
Pilot On
Boiler Status Indicators
Blinking
Boiler Log.txt
True

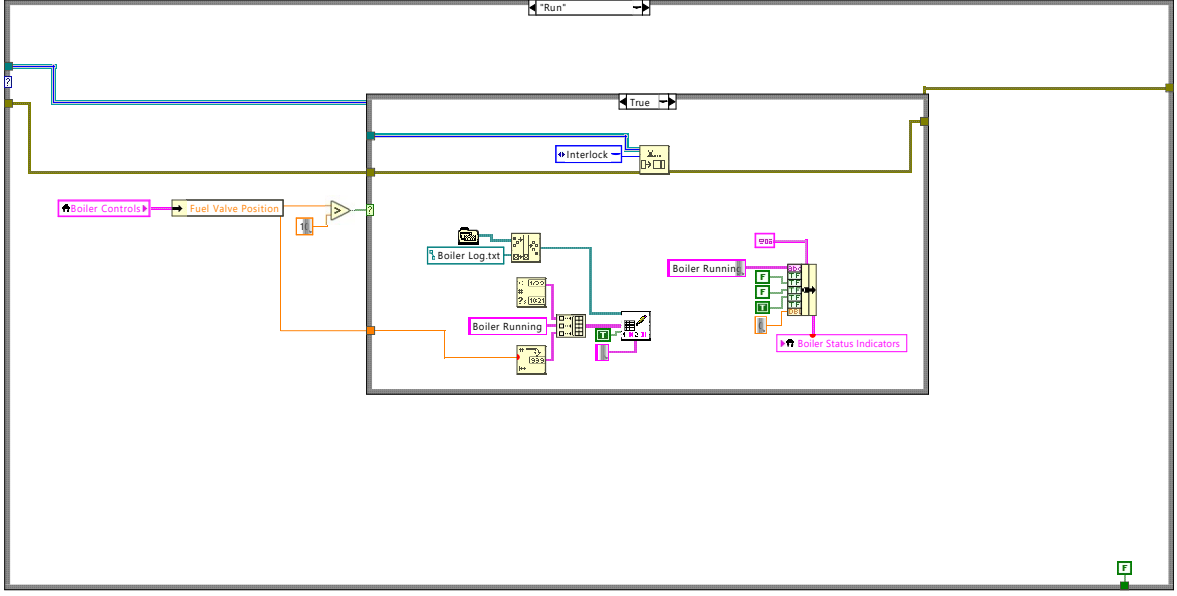

False
Pilot

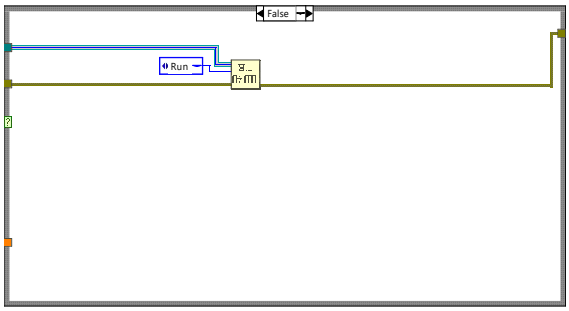

"Ignition"
True
Forced Draft Fan
Boiler Simulation Controls
Flame Sensor Value (%)
Boiler Read
Boiler Status Indicators
Boiler Log.txt
Pilot Proved

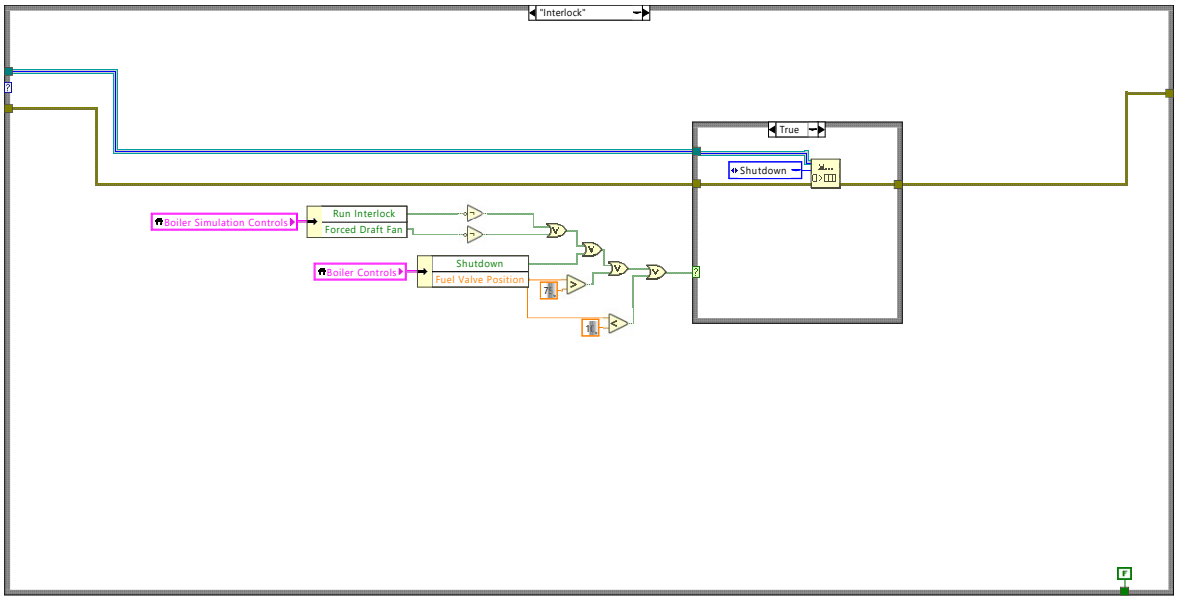

False
Ignition

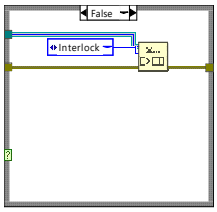

"Forced Draft Fan"
True
Run
Boiler Log.txt
Boiler Simulation Controls
Forced Draft Fan
True
Forced Draft Fan On

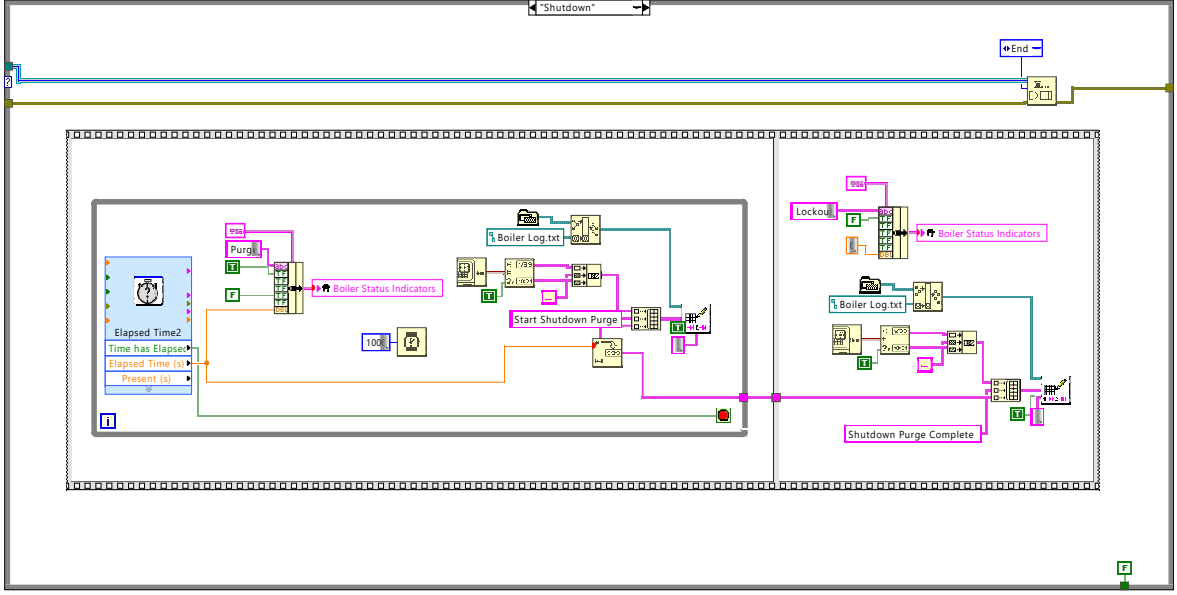

False
Forced Draft Fan

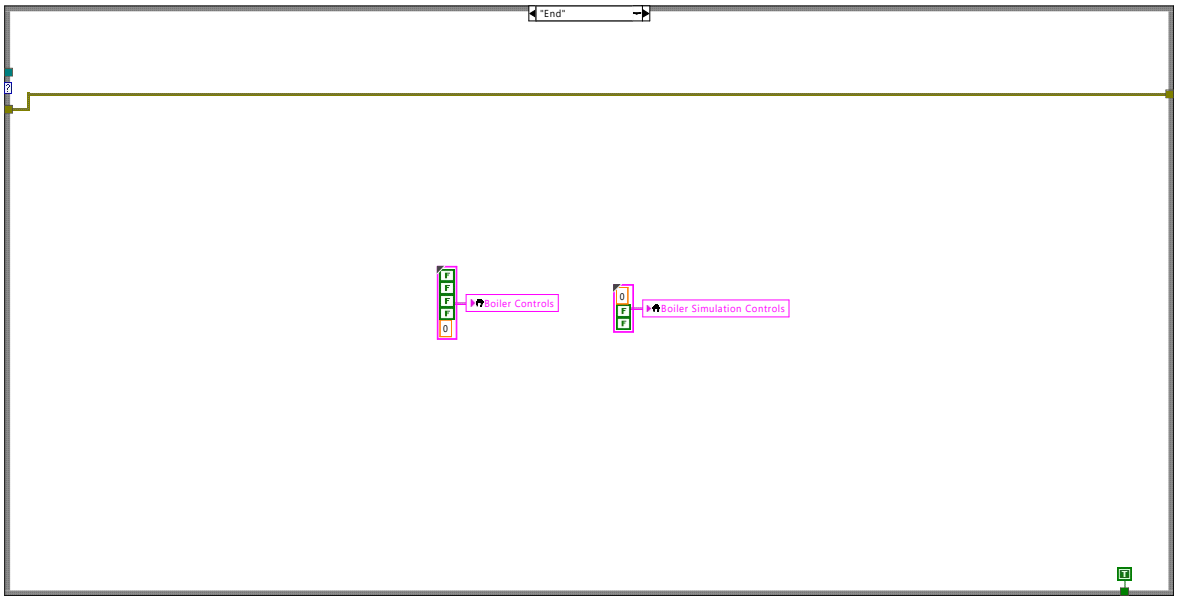

"Run"
True
Interlock
Boiler Controls
Fuel Valve Position
Boiler Log.txt
Boiler Running
Boiler Running
Boiler Status Indicators


False
Run


"Interlock"
True
Shutdown
Boiler Simulation Controls
Run Interlock
Forced Draft Fan
Boiler Controls
Shutdown
Fuel Valve Position


False
Interlock


"Shutdown"
End
Elapsed Time2
Time has Elapsed
Elapsed Time (s)
Present (s)
Purge
Boiler Status Indicators
Boiler Log.txt
100
Start Shutdown Purge
Lockout
Boiler Status Indicators
Boiler Log.txt
Shutdown Purge Complete


"End"
Boiler Controls
Boiler Simulation Controls