

Solar Power Firmware Operation for SGSC-01 Controller

Firmware Rev: 1.5, 29/09/2005

Overview

The following is a description of the firmware operation for the Solar Power hot water controller SGSC-01. The controller basically measures the temperatures of a roof mounted collector and a water storage tank and activates a pump when the collector is at a high enough temperature above the tank temperature to cause a net energy transfer to the water tank (i.e. heat the tank water).

Sensor Inputs

On the controller, there are two tank sensor inputs and a collector sensor input. These inputs are periodically sampled and filtered to produce an internal temperature figure that is used by the control algorithm to make decisions. As there is no need to respond rapidly to temperature changes, a large degree of input filtering is applied to provide a large degree of immunity to electrical noise. The time constant of the filter is in the order of 15 seconds. The sensor readings are also checked for short or open circuit conditions. If the sensor reading is less than 0°C or greater than 186°C the sensor channel is flagged as faulty. The fault flag is automatically reset when the temperature comes back into the above-mentioned range.

Status LED

The status LED output provides a visual indication of the operating status of the controller:

LED mostly on	- Idle, pump off **
1 short flash	- Pump running
2 short flashes	- Sensor fault, pump off

** As this LED output is shared with the communications output, when the LED is on continuously, there will be a short blink every 2 seconds. This small perturbation lasts for approximately 31ms.

Option Link

A two-pin option link is provided which selects between two maximum tank temperatures and whether the control function uses single or two tank thermistors in the control algorithm.

With the link present, the controller uses two thermistors to control the maximum tank water temperature (“Tank Top” and “Tank Bottom” as marked on the controller thermistor connections). One thermistor is normally positioned towards the bottom of the tank and the other is normally positioned towards the top of the tank. The controller will cease heating the tank water if one or both thermistors detect that the

tank water is greater than or equal to 75°C. It will resume heating the tank water once both thermistors are sensing that the temperature has dropped to below 72°C.

With the option link removed, the controller uses a single thermistor to control the maximum tank water temperature (“Tank Bottom” as marked on the controller thermistor connections). The controller will cease heating the tank water once it gets to 85°C or greater. It will then resume heating the tank water once it has dropped to below 82°C.

NOTE: only the bottom tank thermistor temperature is used when deciding whether conditions exist for tank water heating. The top tank thermistor channel is only used, in conjunction with the bottom tank thermistor, to ensure that the tank water temperature does not exceed the maximum limit of 75°C with the option link installed.

Diagnostic Serial Output

The controller has provision for a diagnostic output on a 3 pin 0.1” connector. It provides the following information in a TTL serial asynchronous format:

1. Tank top sensor temperature
2. Tank bottom sensor temperature
3. Solar collector temperature
4. Sensor fault indication
5. Control state
6. Pump running status
7. Option link status
8. Whether the minimum pump time timer has expired.
9. Whether the fault recovery timer has expired
10. Firmware revision
11. Average temperature per hour over the last 72 hours for all three temperature channels (mini data logging function)

A purpose built PC application, “SolaMon”, has been written for the PC to allow this information to be displayed and logged. A purpose built adaptor cable is also required to connect the controller to the PC.

Master Control State machine

This firmware module embodies the actual operational characteristics of the controller and its state is available as part of the diagnostic serial data communications. The state number emitted by the controller defines exactly what the operational status is at any time. It consists of 9 “states”, numbered 0 → 8 which correspond conditions in which the controller will reside depending on previous stimuli. This state number is the same state number emitted by the controller as part of the diagnostic communications data.

State 0. Initialisation. In this state we start a 2 second power-on delay timer. This state number will not be seen by SolaMon as it is transitory.

- State 1. Initialisation.** In this state the controller is waiting for the power-on delay timer to expire before turning the pump on and starting a 60 second timer.
- State 2. Run pump at turn on.** In this state the controller is waiting for the 60 second pump activation at power up timer to expire before turning the pump off and changing to the idle state, state 3. Note the minimum pump time indicator will be lit on “SolaMon”, even though the pump run time is only one minute.
- State 3. Idle.** This is the idle state for the controller. If there is a sensor error, it changes to state 7 to wait for it to be fixed. Otherwise, it checks the tank temperature to determine whether it is greater than the maximum allowed water temperature (as set by the option link), and if it is it changes to state 4. The temperature differential between the collector and the bottom tank sensors is checked. If the collector is hotter than the tank by at least 10°C degrees Celsius, we turn on the pump and start the minimum pump run time timer (15 minutes) before changing to state 6.
- State 4. Tank water too hot.** In this state, the tank temperature is greater than the allowed limit (as set by the option link), the pump is off and the tank temperature is monitored until it has dropped below this threshold, minus a few degrees of hysteresis (as set by the option link). When it has cooled sufficiently, it changes back to state 3. It also checks to see if the collector requires frost protection. If it does we start the pump, the minimum pump run timer (15 minutes), and change to state 5.
- State 5. Collector frost protection.** In this state, the collector temperature was below the defrost threshold and it is now pumping hot water from the tank through the collector coils to protect them from the effects of the water freezing in the tubing. We continue to pump for at least 15 minutes, unless a sensor fault is detected, in which case the pump is stopped and we change to state 7.
- State 6. Heating tank water.** In this state, the temperature differential between the collector temperature and tank temperature is greater than or equal to 10°C and the pump has been turned on. The pump now runs until the minimum pump on timer expires and the temperature differential remains above 4°C. If the tank temperature exceeds the allowed limit (as set by the option link), the pump is immediately shut off and we change to state 4. If either of the sensors becomes faulty, we change to state 7.
- State 7. Sensor fault.** In this state one or both of the sensors are in fault and we remain in this state until the fault is cleared, before changing to state 8. While in this state, a timer is re-triggered so that when there are no faults, the unit remains inactive for 15 minutes from when the last fault was rectified.
- State 8. Fault recovery timer running.** In this state we wait for the timer started in state 7 to expire before changing back to state 3. If a sensor fault is detected, we change back to state 7.

“Watchdog”

The firmware makes use of a feature in the microprocessor chip called a watchdog timer. This feature is turned on at initialisation time by the firmware and must be serviced at regular intervals by the firmware or the chip automatically reset (ie re-starts the program). This feature guards against the unlikely event of a “runaway” processor and uses a separate internal clock for maximum independence from the processor’s own instruction execution clock.

Data Logging

The controller has a non volatile data logging function built into it that allows the PC application “SolaMon” to graph and save the last 72 hours of tank and collector temperatures. The data logger stores the average temperature readings on an hourly basis, for all temperature channels. Two hundred and fifty six temperature readings are taken every 14.063 seconds to give an average over one hour. The data logging is non volatile so that data is not lost when the power is interrupted, but data logging does not continue with the power off.

SolarMon Compatibility

This firmware for the SGSC-01 can only be used in conjunction with SolaMon 3.0 or greater. However, SolarMon 3.0 is backward compatible with the previous controller and firmware 1.3. SolarMon dynamically changes screens to suit the firmware revision, and in the case of SGSC-01 version 1.5 firmware, it also changes screens depending on whether the option link is present or not.