INSTRUCTION MANUAL

CS700 Tipping Bucket Rain Gage and CS700H Heated Rain Gage

Revision: 7/11

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PLEASE READ FIRST

About this manual

Please note that this manual was originally produced by Campbell Scientific Inc. (CSI) primarily for the US market. Some spellings, weights and measures may reflect this origin.

Some useful conversion factors:

Area:	1 in^2 (square inch) = 645 mm^2
Length:	1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km
Mass:	1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Pressure:	1 psi (lb/in2) = 68.95 mb
Volume:	1 US gallon = 3.785 litres

In addition, part ordering numbers may vary. For example, the CABLE5CBL is a CSI part number and known as a FIN5COND at Campbell Scientific Canada (CSC). CSC Technical Support will be pleased to assist with any questions.

CS700 and CS700H Table of Contents

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CS700 and CS700H Rain Gage

1. General Description

The CS700 tipping bucket rain gage is manufactured by Hydrological Services Pty. Ltd. (Model TB-3), and modified for use with Campbell Scientific dataloggers (see Figure 1-1). It catches rainfall in the 200 mm collection funnel. When 0.2mm of rainfall is collected, the tipping bucket assembly tips and activates a reed switch. The switch closure is recorded by the datalogger. After the bucket tips, the water drains out the screened base of the gage.

The CS700H is a heated version of the CS700 that can measure the water content of snow (see Figure 1-1). It includes an internal snow sensor that is activated when the air temperature drops below 4°C. If the snow sensor detects snow in the catch area (funnel), the heating elements automatically turn on and keep the funnel temperature at +10°C. The heater goes into a wait mode when snow has not been detected for 18 minutes then automatically deactivates when the air temperature drops below -20°C.

The CS700H has two power configuration options (either AC or DC). With the AC option, a Phoenix Contact Power Supply is shipped with the CS700H. With the DC option, the CS700H is connected to a user-supplied battery. This option is ideal for remote sites using wind or solar power to recharge the battery. Battery capacity requirements vary according to the application and site location.

NOTE Appendix A provides detailed information about the CS700H's operation.

Both the CS700 and CS700H feature a heavy-duty, cast aluminum housing and base; a dual-reed switch potted in soft silicon rubber with varistor protection; and a siphon that allows the precipitation to flow at a steady rate regardless of rainflow intensity. The siphon reduces typical rain bucket errors and produces accurate measurements over a range of 0 to 700mm/hr.

NOTE The 260-953 Alter-Type Wind Screen can be used with the CS700 and CS700H to minimize the effects of strong winds.

The "-L" after the model CS700 (CS700-L) or CS700H (CS700H-L) indicates that the cable length is user specified when ordering. This manual refers to the sensor as the CS700 or CS700H.

The CS700 and CS700H ship with:

(1) Allen Wrench from Original Mfg.
(1) Instruction Manual

CS700H-AC Version also ships with:
(1) Power Supply and Mounting Hardware (Quint Power made by Phoenix Contact)

FIGURE 1-1. The CS700 (left) and CS700H (right).

2. Specifications

Orifice Diameter:	200 mm
Measurement Range:	0 to 700 mm/hr
Accuracy:	better than ±2% @ 500 mm/hr
Resolution:	0.2 mm
Temperature Range	
CS700:	0° to +70°C
CS700H:	-40° to 70°C
Humidity:	0 to 100%
Contact:	Dual Reed Switch
Dimensions	
Height:	342 mm
Diameter:	244 mm
Weight:	7.4 lb (3.4 kg) w/ 25 ft signal cable

NOTE The black outer jacket of the cable is Santoprene® rubber. This compound was chosen for its resistance to temperature extremes, moisture, and UV degradation. However, this jacket will support combustion in air. It is rated as slow burning when tested according to U.L. 94 H.B. and will pass FMVSS302. Local fire codes may preclude its use inside buildings.

2.1 Heated Rain Gage

Snow Sensor and Heater
Operating Temperature Range: -20° to +5°C

Output: SDI-12

Voltage Requirements
Main Power: 10 to 30 Vdc or 12 to 28 Vac
SDI-12 Power: 9.6 to 16 Vdc

Total Current Consumption (See Figure 2-1)
Snow sensor off, heater off: 6 mA @ 12 V, 0.072 W
Snow sensor on, heater off: 12 mA @ 12 V, 0.144 W
Snow sensor on, heater on: 5.8 A @ 12 V, 70 W

As the ambient temperature falls below the "Active On Temperature" (default 4°C), the heater will turn on to heat the funnel area of the rain gauge. Once the funnel reaches the "Funnel Set Point Temp" (default 10°C), the heater will begin cycling on and off with a duty cycle dependent on the ambient temperature, keeping the funnel temperature at or near 10°C.

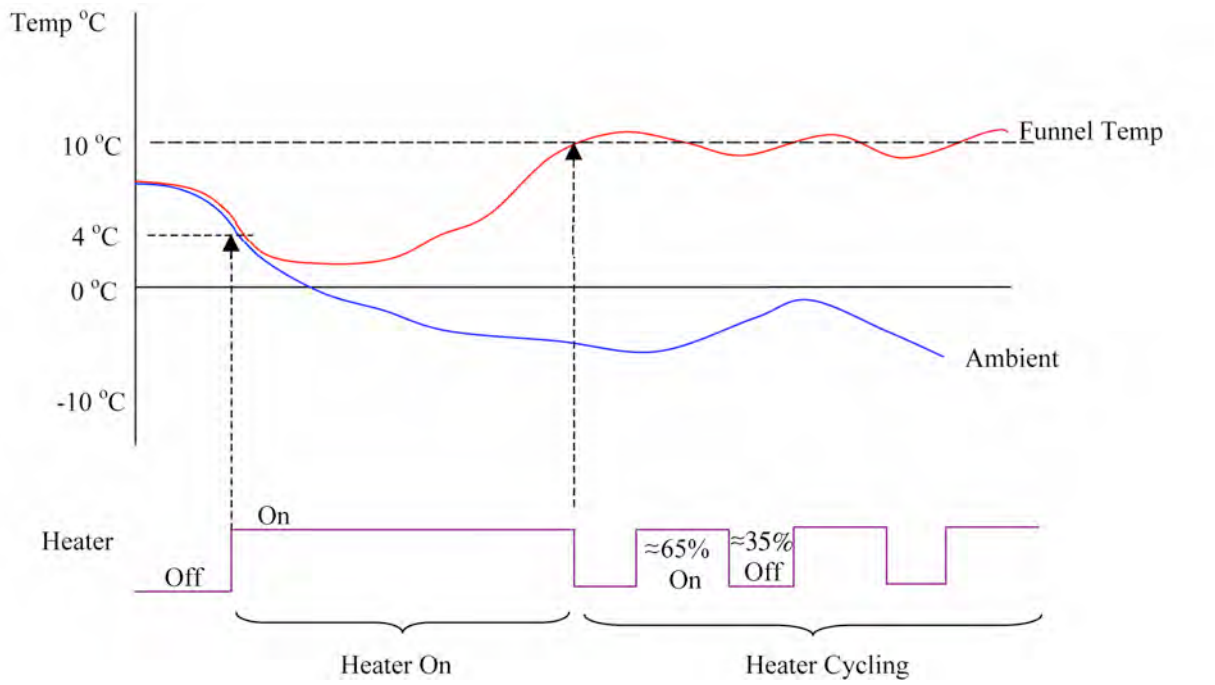

FIGURE 2-1. Heater Operation

2.1.1 Phoenix Contact Power Supply (AC option only)

Model Name:	Quint-PS/1AC/24DC/10
Input data	
Nominal input voltage:	100 Vac to 240 Vac
AC input voltage range:	85 Vac to 264 Vac
Short-term input voltage:	300 Vac
AC frequency range:	45 Hz to 65 Hz
Name of protection:	Transient surge protection
Protective circuit/component:	Varistor
Output data	
Nominal output voltage:	24 Vdc ±1%
Setting range of the output voltage:	18 Vdc to 29.5 Vdc (>24 V constant capacity)
Output current:	10 A (-25°C to 60°C, U_{OUT} = 24 Vdc) 15 A (with POWER BOOST, -25°C to 40°C permanently, U_{OUT} = 24 Vdc)
Derating:	From +60°C to 70°C: 2.5% per Kelvin
Connection in parallel:	Yes, for redundancy and increased capacity
Connection in series:	Yes
Maximum power dissipation idling:	7 W
Power loss nominal load max.:	18 W

General data	
Width:	2.4 in. (60 mm)
Height:	5.1 in. (130 mm)
Depth:	4.9 in. (125 mm)
Weight:	2.4 lb. (1.1 kg)
Efficiency:	> 92.5% (for 230 Vac and nominal values)
Ambient temperature (operation):	-25°C to 70°C (> 60°C derating)
Ambient temperature (storage/transport):	-40°C to 85°C
Max. permissible relative humidity (operation):	95% (at 25°C, no condensation)

NOTE Additional specifications are provided in Phoenix Contact's manual for the Quint-PS/1AC/24DC/10.

3. Installation

NOTE The 260-953 Alter-type Wind Screen's siting information and installation procedure are provided in our 260-953 manual.

3.1 Location

The CS700 and CS700H should be mounted in a relatively level spot which is representative of the surrounding area. The ground surface around the rain gage should be natural vegetation or gravel. The gage should not be installed over a paved or concrete surface.

For accurate measurements, the CS700 and CS700H must be placed away from objects that obstruct wind. The minimum distance should be at least 2 to 4 times the height of the obstruction.

3.2 Mounting

The CS700 and CS700H are designed to mount on a flat surface. Three equally spaced mounting pads are provided. The mounting pads are pre-drilled for three 3/8" (M8) bolts on a 9.21" (234 mm) diameter bolt circle.

The CM240 mounting bracket is available from Campbell Scientific for installing the CS700 and CS700H (see Figure 3-1). The CM240 base helps level the rain gage, ensuring a more accurate measurement. The base may be attached to a CM300-Series Mounting Pole or to a user-supplied 1.5 in. IPS (1.9 in. OD) unthreaded pipe. The pipe should be long enough to place the gage's orifice at a one-meter height. The rain gage should be high enough to be above the average snow depth. The pole or pipe can be placed directly into a concrete foundation (see Figure 3-2), or attached to a concrete foundation using J-bolts or self-supporting with legs (see Figure 3-3). A concrete pad is recommended, but it should not be installed over large paved or concrete surface.

FIGURE 3-1. CM240 Mounting Bracket

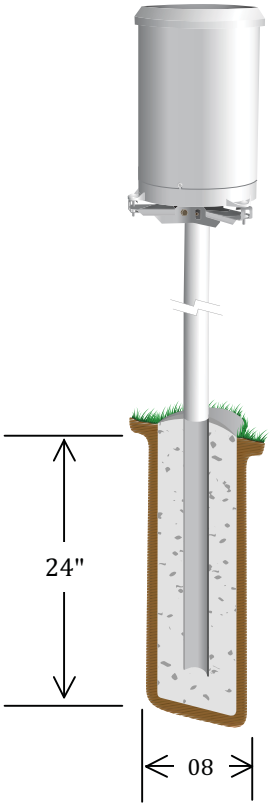

FIGURE 3-2. Typical Rain Gage Installation

FIGURE 3-3. Pedestal Base Options

3.3 Leveling

Level the rain gage after mounting it. To level, remove the housing assembly from the base by loosening the three housing screws and lifting the housing upward. Adjust the three nuts on the CM240 bracket to level the gage. A bullseye level is mounted on the rain gage's base to facilitate leveling (see Figure 3-4).

Remove the rubber shipping band and cardboard packing securing the tipping bucket assembly. Tip the bucket several times to insure the tipping mechanism is moving freely. Replace the housing assembly and tighten the three screws to secure the housing to the base.

FIGURE 3-4. Main Components of the CS700

3.4 CS700H Phoenix Contact Power Supply (-AC option)

Because the Phoenix Contact Power Supply must be housed in an environmental enclosure, the CS700H includes a DIN Rail mounting bracket. The DIN Rail mounts to an enclosure backplate via screws and grommets.

4. Wiring

When Short Cut software is used to generate the datalogger program, the sensor should be wired to the channels shown on the wiring diagram created by Short Cut.

NOTE The CS700 Tipping Bucket Rain Gage and CS700H Heated Rain Gage are wired differently.

4.1 CS700 Connections

The CS700 is typically wired to a datalogger's pulse channel (see Table 4-1).

TABLE 4-1. CS700 Wiring for Pulse Channel Input

Color	Description	CR800, CR850 CR1000 CR3000 CR5000	CR510 CR500 CR10(X)	21X CR7 CR23X	CR200(X) Series
Black	Signal	Pulse Channel	Pulse Channel	Pulse Channel	P_SW
White	Signal Return	⏚	G	⏚	⏚
Clear	Shield	⏚	G	⏚	⏚

NOTE Dataloggers listed in Table 4-2 have the capability of counting switch closures on some of their control ports. When a control port is used, the return from the rain gage switch must be connected to +5 volts on the datalogger.

TABLE 4-2. CS700 Wiring for Control Port Input

Color	Description	CR800 CR850 CR1000 CR3000	CR500 CR510	CR10X	CR23X
Black	Signal	Control Port (e.g., C1-C8)	C2/P3	Control Port (e.g., C1-C8)	Control Port (e.g., C1-C8)
White	Signal Return	5 V	5 V	5 V	5 V
Clear	Shield	⏚	⏚	G	⏚

The CR10 does not support the use of control port inputs with the Pulse Count instruction.

FIGURE 4-1. Rain Gage Schematic

Long cables have appreciable capacitance between the lines. A built up charge could cause arcing when the switch closes, shortening switch life. A 100 ohm resistor is connected in series at the switch to prevent arcing by limiting the current (Figure 4-1). This resistor is installed on all rain gages currently sold by Campbell Scientific.

4.2 CS700H Heated Rain Gage Connections

The CS700H sensor cable can be wired to the datalogger's pulse channels (see Table 4-3). The sensor cable can also be wired to the datalogger control ports instead of pulse channels (see Table 4-4).

TABLE 4-3. CS700H Sensor Cable Wiring for Pulse Channel Inputs

Color	Description	CR800, CR850, CR1000, CR3000, CR5000	CR10X, CR23X
Green	SDI-12	SDI-12 compatible Control Port (e.g., C1, C3, C5, C7)	SDI-12 compatible Control Port (e.g., C1-C8)
Red	12V	12V	12V
Black	0V	G	G
Blue	Signal A	Pulse Channel (e.g., P1, P2)	Pulse Channel (e.g., P1, P2)
White	Signal Reference	⏚	G
Yellow	Signal B	Pulse Channel (e.g., P1, P2)	Pulse Channel (e.g., P1, P2)
Brown	Signal Return	⏚	G

TABLE 4-4. CS700H Sensor Cable Wiring for Control Port Inputs

Color	Description	CR800, CR850, CR1000, CR3000, CR5000	CR10X, CR23X
Green	SDI-12	SDI-12 compatible Control Port (e.g., C1, C3, C5, C7)	SDI-12 compatible Control Port (e.g., C1-C8)
Red	12V	12V	12V
Black	0V	G	G
Blue	Signal A	Control Port (e.g., C1-C8)	Control Port (e.g., C1-C8)
White	5V	5V	5V
Yellow	Signal B	Control Port (e.g., C1-C8)	Control Port (e.g., C1-C8)
Brown	5V	5V	5V

The power cable is wired to the power supply (see Table 4-5). Figure 4-2 shows the terminals for connecting the power cable to the Phoenix Contact Power Supply.

TABLE 4-5. CS700H Power Cable Wiring

Color	Description	Power Supply
Red	+24 VDC	+24 V
Black	-24 VDC	-24 V

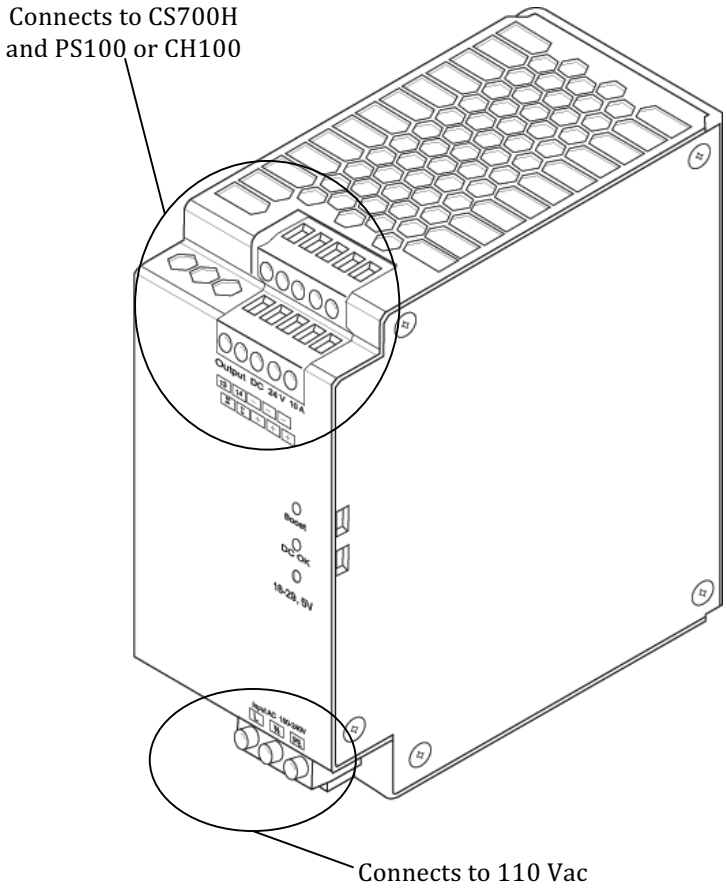

FIGURE 4-2. Phoenix Contact Power Supply

5. Datalogger Programming

This section is for users who write their own datalogger programs. A datalogger program to measure this sensor can be created using Campbell Scientific's Short Cut Program Builder software. You do not need to read this section to use Short Cut.

5.1 CS700 Programming

The CS700 is measured using the Pulse Count instruction with the switch closure configuration code. The multiplier used in the Pulse Count instruction determines the units in which rainfall is reported. In all dataloggers, a multiplier of 0.2 converts the output to millimeters.

5.1.1 CS700 Pulse Channel Example Programs

The following example programs use a pulse channel to read the output from the CS700.

5.1.1.1 CR1000 Pulse Channel Example

Although this example is for the CR1000, the CR800, CR850, CR3000, and CR5000 are programmed similarly.

```
'CR1000
'CR1000 Program for CS700

'Declare Variables and Units
Public Rain_mm

Units Rain_mm=mm

'Define Data Tables
DataTable(CS700_mm,True,-1)
    DataInterval(0,60,Min,0)
    Totalize(1,Rain_mm,IEEE4,0)
EndTable

'Main Program
BeginProg
    Scan(1,Sec,1,0)
        'CS700 Rain Gauge measurement Rain_mm:
        PulseCount(Rain_mm,1,1,2,0,0.2,0)
        'Call Data Tables and Store Data
        CallTable(CS700_mm)
    NextScan
EndProg
```

5.1.1.2 CR200(X) Series Pulse Channel Example

```
'CR200 Series
'CS700 program

'Declare Variables and Units
Public Rain_mm

Units Rain_mm=mm

'Define Data Tables
DataTable(CS700_mm,True,-1)
    DataInterval(0,60,Min)
    Totalize(1,Rain_mm,0)
EndTable

'Main Program
BeginProg
    Scan(10,Sec)
        'CS700 Rain Gauge measurement Rain_mm:
        PulseCount(Rain_mm,P_SW,2,0,0.2,0)
        'Call Data Tables and Store Data
        CallTable(CS700_mm)
    NextScan
EndProg
```

5.1.1.3 CR10X Pulse Channel Example

Although this program is for the CR10(X), the CR500, CR510, CR23X, and 21X can use essentially the same program. The CR7 is programmed similarly but has an additional parameter in the Pulse Count instruction that specifies the slot that the pulse card is in.

```
;{CR10X}
;
;CR10X Program for CS700
;Rain (mm)
;
*Table 1 Program
  01: 1             Execution Interval (seconds)

1: Pulse (P3)
  1:  1             Reps
  2:  1             Pulse Channel 1
  3:  2             Switch Closure, All Counts
  4:  1             Loc [ Rain_mm   ]
  5:  0.2           Multiplier
  6:  0             Offset

2: If time is (P92)
  1:  0             Minutes (Seconds --) into a
  2:  60            Interval (same units as above)
  3:  10            Set Output Flag High (Flag 0)
```

```
3:  Set Active Storage Area (P80)
   1:   1              Final Storage Area 1
   2:   101            Array ID

4:  Real Time (P77)
   1:   1220           Year,Day,Hour/Minute (midnight = 2400)

5:  Totalize (P72)
   1:   1              Reps
   2:   1              Loc [ Rain_mm   ]

*Table 2 Program
   02:  0.0000         Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

Output Instruction 72, Totalize, is used in the output section of the program to output the total rainfall over the output interval. This section should be executed every scan and not placed in a subroutine or conditional statement.

5.1.2 Control Port Example Programs

The following examples measure a CS700 rain gage using a control port on the datalogger. Wire the sensor as shown in Table 4-2.

5.1.2.1 CR1000 Control Port Example

Although this example is for the CR1000, the CR800, CR850, and CR3000 are programmed similarly.

```
'CR1000
'CR1000 Program for CS700

'Declare Public Variables and Units
Public Rain_mm
Units Rain_mm=mm

DataTable (Rain,True,-1)
    DataInterval (0,60,Min,0)
    Totalize (1,Rain_mm,FP2,0)
EndTable

'Main Program
BeginProg
    Scan (1,Sec,1,0)
        PulseCount (Rain_mm,1,18,2,0,0.2,0)      ; Black wire connected to C8
        CallTable (Rain)
    NextScan
EndProg
```

5.1.2.2 CR200(X) Series Control Port Example

```
'CR200

' A 20 kOhm pull up resistor is required to read a switch closure on C1 or C2
' as a Pulse Counter. The 20 kOhm resistor uses the battery voltage.

'Declare Public Variables and Units
Public Rain_mm
Units Rain_mm=mm

'Define Data Tables
DataTable (Rain,True,-1)
    DataInterval (0,60,min)
    Totalize (1,Rain_mm,0)
EndTable

'Main Program
BeginProg
    Scan (1,Sec)
        'CS700 Rain Gage measurement Rain-mm
        PulseCount (Rain_mm,C2,2,0,0.2,0)        ; Black wire connected to C2
        'Call Data Tables and Store Data
        CallTable (Rain)
    NextScan
EndProg
```

5.1.2.3 CR10X Control Port Example

Although this example is for the CR10X, the CR23X is programmed similarly.

```
;{CR10X}
*Table 1 Program
  01: 1.0000        Execution Interval (seconds)

1: Pulse (P3)
  1:  1             Reps
  2:  8             Control Port 8 (switch closure only); Black wire connect to C8
  3:  2             Switch Closure, All Counts
  4:  1             Loc [ Rain_mm   ]
  5:  0.2           Multiplier
  6:  0             Offset

2: If time is (P92)
  1:  0             Minutes (Seconds --) into a
  2:  60            Interval (same units as above)
  3:  10            Set Output Flag High (Flag 0)

3: Set Active Storage Area (P80)
  1:  1             Final Storage Area 1
  2:  101           Array ID

4: Real Time (P77)
  1:  1220          Year,Day,Hour/Minute (midnight = 2400)
```

```
5:  Sample (P70)
   1:   1              Reps
   2:   1              Loc [ Rain_mm   ]

*Table 2 Program
   01:  0.0000         Execution Interval (seconds)

*Table 3 Subroutines

End Program
```

5.2 CS700H Programming

The CS700H has a dual reed switch for measuring precipitation. A separate pulse count instruction is used to measure each of the reed switches. The SDI-12 recorder instruction is used to receive real time status of the microprocessor located inside the tipping bucket.

NOTE Appendix A provides more information about the SDI-12 commands and other operational details for the CS700H.

5.2.1 CS700H Example Program

Although this program is for the CR1000, the CR800, CR850, and CR3000 are programmed similarly.

```
'CR1000 Series Datalogger
'CS700H-L SDI-12 Grn > C1
' Red > 12v
' Blk > 0v
' Tipping A Blu > C2
' Wht > 5v
' B Yel > C3
' Brn > 5v

'Declare Variables and Units
Public PTemp
Public BattV
Public CH700HA      'reed switch A
Public CH700HB      'reed switch B
Public Info(9)

Alias Info(1)=CS700H_AirTemp
Alias Info(2)=CS700H_BlockTemp
Alias Info(3)=CS700H_C0_F1
Alias Info(4)=CS700H_NoSnow0_Snow1
Alias Info(5)=CS700H_SnwSnsrActv
Alias Info(6)=CS700H_Htr_On_off
Alias Info(7)=CS700H_Control_Auto_Man
Alias Info(8)=CS700H_Cycle_Dis_Ena
Alias Info(9)=CS700H_LPHTimeLeft
```

```
Units BattV = Volts
Units CH700HA =inch
Units CH700HB =inch

'Define Data Tables
DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize (1,CH700HA,FP2,False)
  Totalize (1,CH700HB,FP2,False)
  Sample (1,CS700H_AirTemp,FP2)
  Sample (1,CS700H_BlockTemp,FP2)
  Sample (1,CS700H_C0_F1,FP2)
  Sample (1,CS700H_NoSnow0_Snow1,FP2)
  Sample (1,CS700H_SnwSnsrActv,FP2)
  Sample (1,CS700H_Htr_On_off,FP2)
  Sample (1,CS700H_Control_Auto_Man,FP2)
  Sample (1,CS700H_Cycle_Dis_Ena,FP2)
  Sample (1,CS700H_LPHTimeLeft,FP2)
EndTable

DataTable(OneDay,True,-1)
  DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize (1,CH700HA,FP2,False)          'CH700H tipping bucket a
  Totalize (1,CH700HB,FP2,False)          'CH700H tipping bucket b
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
    'Default Datalogger Battery Voltage measurement BattV
    PanelTemp (PTemp,_60Hz)
    Battery(BattV)
    'SDI-12 Sensor measurements
    SDI12Recorder(Info(),1,"0","M!",1,0)
    'CS700H Rain Gauge measurement Rain_in
    PulseCount(CH700HA,1,12,2,0,0.2,0)
    'CS700H Rain Gauge measurement Rain_in
    PulseCount(CH700HB,1,13,2,0,0.2,0)
    'Call Data Tables and Store Data
    CallTable(OneMin)
    CallTable(OneDay)
  NextScan
EndProg
```

6. Troubleshooting

6.1 Precipitation

Symptom: No Precipitation

1. Check that the sensor is wired to the Pulse Channel specified by the pulse count instruction.

2. Verify that the Configuration Code (Switch Closure), and Multiplier and Offset parameters for the Pulse Count instruction are correct for the datalogger type.

3. Disconnect the sensor from the datalogger and use an ohm meter to do a continuity check of the switch. The resistance measured at the terminal block on the inside of the bucket between the black and white leads should vary from infinite (switch open) when the bucket is tipped, to less than an ohm when the bucket is balanced.

7. Maintenance

During each site visit, remove any debris, insects, sediment, etc. from the collection funnel, debris screen, siphoning mechanism, or tipping bucket assembly.

Verify the tipping bucket assembly moves freely, and that the datalogger records each bucket tip.

7.1 Dismantling for Cleaning

The following items should be checked regularly for cleanliness:

- Catch filter (see Figure 7-3)
- Siphon (see Figure 7-3)
- Interior of bucket (see Figure 7-1)
- Top surface of adjusting screws (see Figure 7-1)
- Housing locking screws; lightly lubricate after cleaning (see Figure 7-1)
- All insect screens (see Figure 7-1)

To access the above components, dismantle the CS700 using the following procedure:

1. Remove the housing assembly from the base by loosening the three locking screws and lifting the housing upward.

FIGURE 7-1. Components of CS700 Base

2. Separate the filter/siphon assembly from the funnel by pushing the filter while pulling the siphon (see Figure 7-2).

CAUTION Do not twist the filter/siphon assembly while pushing and pulling.

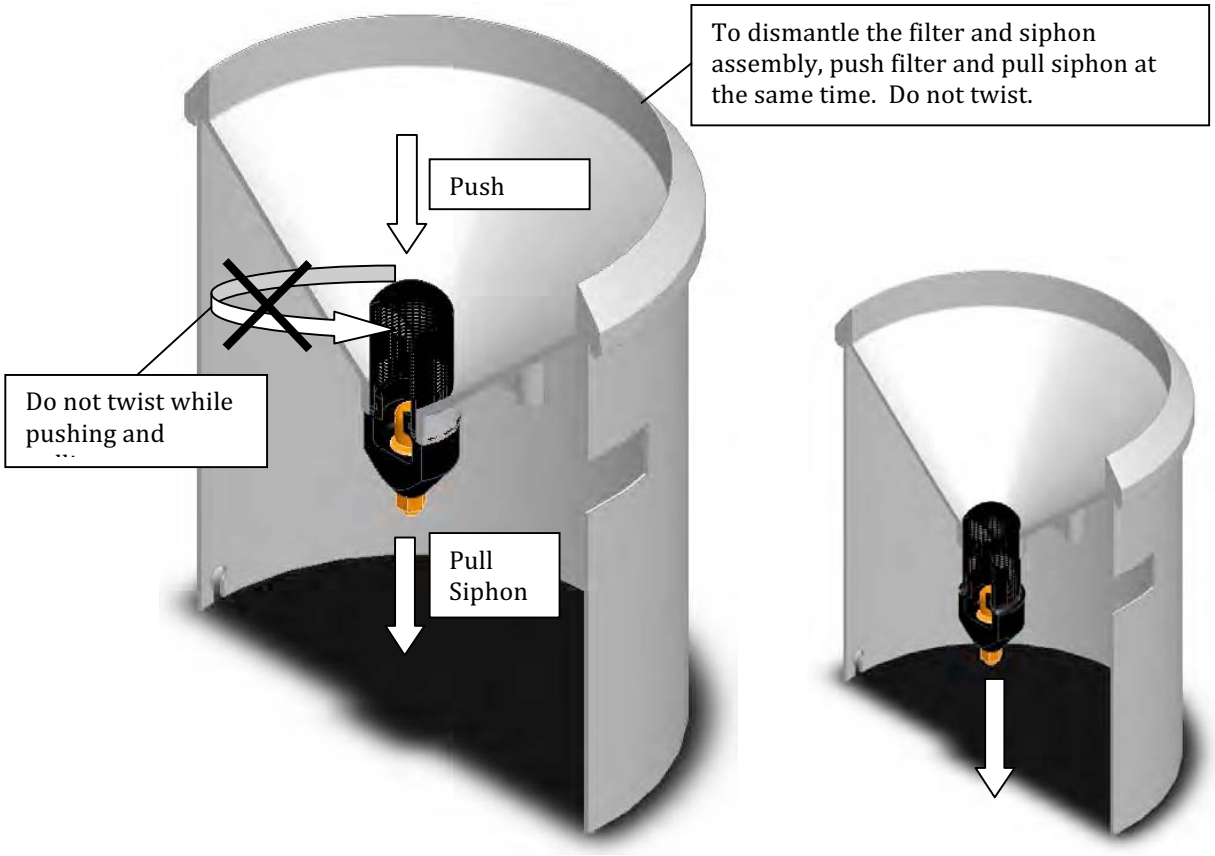

FIGURE 7-2. Dismantling the Filter/Siphon Assembly

3. Disassemble the filter/siphon assembly by doing the following (see Figure 7-3):

   (a) Unscrew nut
   (b) Lightly press stem down on surface until stem pops out of siphon body.
   (c) Remove stem from siphon body.
   (d) Unscrew cap
   (e) Clean all items

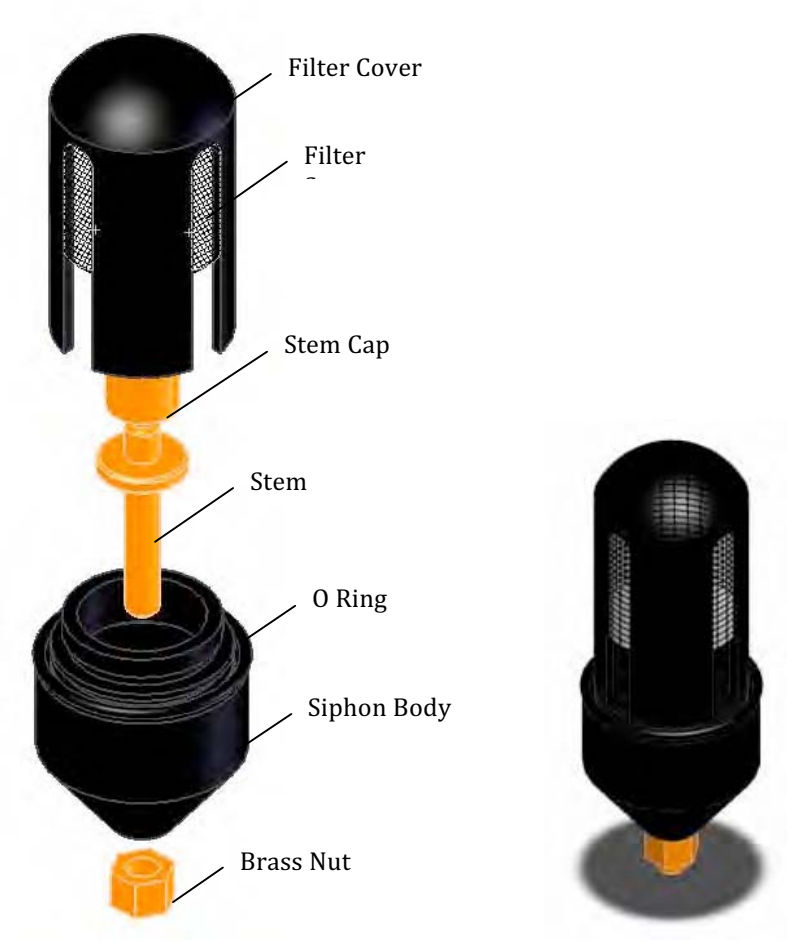

FIGURE 7-3. Filter/Siphon Assembly

7.2 Reassembling the CS700

1. Screw cap on stem, finger tighten only (see Figure 7-3).
2. Push stem into siphon body (see Figure 7-3).
3. Replace nut and tighten (see Figure 7-3).

CAUTION Do not over tighten.

4. Push filter/siphon assembly back into place (see Figure 7-4).

CAUTION Do not twist the filter/siphon assembly while putting it back into place.

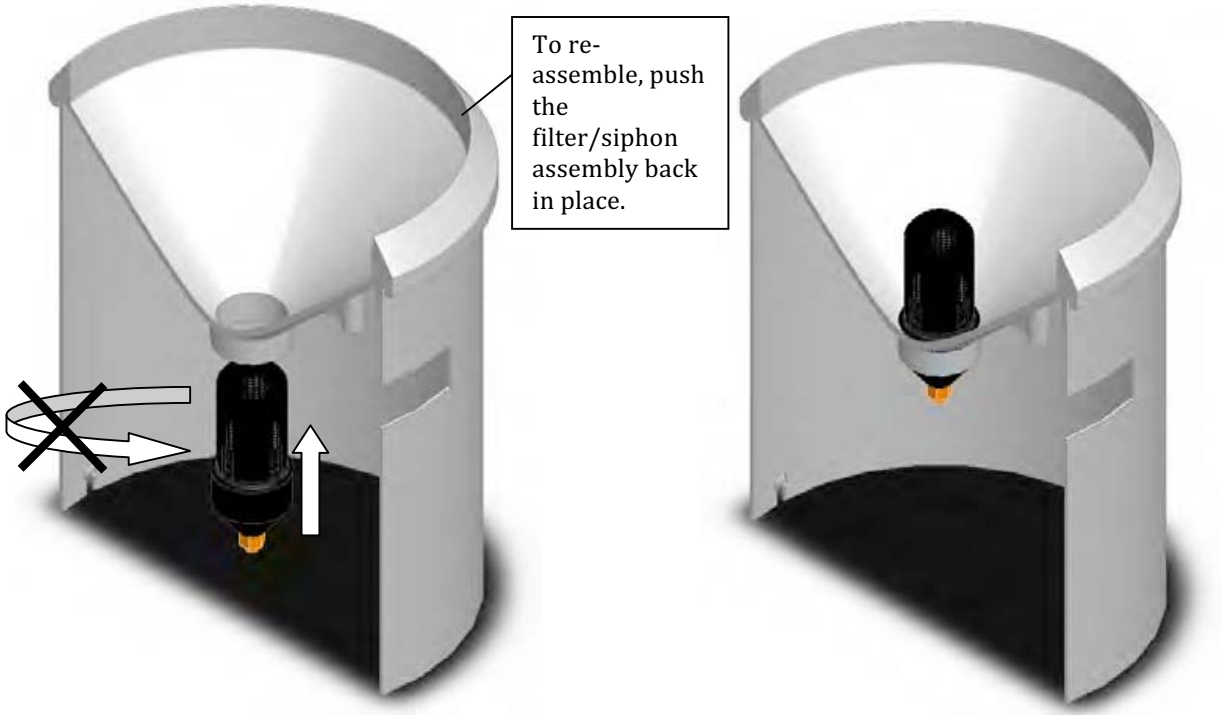

FIGURE 7-4. Reassembling the CS700

5. Place the housing assembly back onto the base and tighten the three screws that secure the housing onto the base.

8. Calibration

The sensor is factory calibrated; recalibration is not required unless damage has occurred or the adjustment screws have loosened.

Nevertheless, the following calibration check is recommended once every 12 months:

a. Remove the housing assembly from the base by removing the three screws and lifting upward on the housing.

b. Check the bubble level to verify the rain gage is level.

c. Pour water through the inner funnel to wet the two bucket surfaces. Using a graduated cylinder, slowly pour 314 cc (19.16 in^3) of water, over a 15 minute period, into the collection funnel. This volume of water is equal to .39 in of rainfall (10 mm).

d. After the water has passed through the rain gage, the tipping bucket should have tipped 39 times.

e. If the rain gage fails to record the correct number of tips, return the unit to Campbell Scientific for recalibration.

Factory Calibration

If factory calibration is required, contact Campbell Scientific to obtain an RMA (see Warranty and Assistance in the front of the manual).

Appendix A. CS700H Operation

CAUTION Factory settings have been set to adequately measure precipitation during cold precipitation events. Changing these settings is not recommended, and doing so may change the data outcome or render the sensor inoperable.

Table A-1 shows the CS700H's factory defaults:

TABLE A-1. CS700H Default Values

External Control Off (=> Auto)	(X20 Command) = 0
Snow Sensor Enabled	(X22 Command) = 1
Active On Temperature +4°C	(X23 Command)
Active Off Temperature+5°C	(X24 Command)
Low Off Temperature –20°C	(X25 Command)
Funnel Set Point Temp +10°C	(X26 Command)
Snow Run-On Time 18 mins	(X27 Command)
Units °C	(X28 Command) = 0

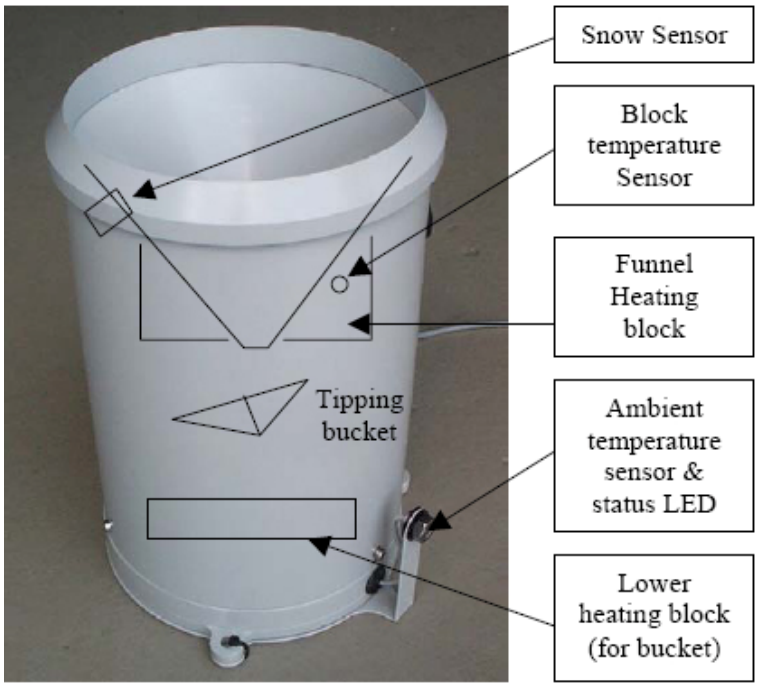

FIGURE A-1. Locations of the CS700H's Heater Components

When the CS700H is "**not** Active" the status LED flashes every 1.5 seconds.

When the ambient temperature sensor detects the temperature falling below the "Active On temperature" (+4°C) then the system becomes "Active" and the snow sensor is enabled (see Figure A-2). The status LED flashes slightly faster at 2 flashes per second–indicating the system is active.

When the proximity sensor detects snow (for 5 seconds continuously), the heater elements are turned on and the block temperature sensor is monitored. The heaters are controlled so that the temperature inside the funnel reaches the Set Point temperature (+10°C).

NOTE The actual block temperature will be higher than the set point as substantial heat is dissipated.

The lower heating block keeps the tipping bucket and the drain tubes from freezing up. While the heater elements are turned on, the status LED flashes even faster at eight flashes per second.

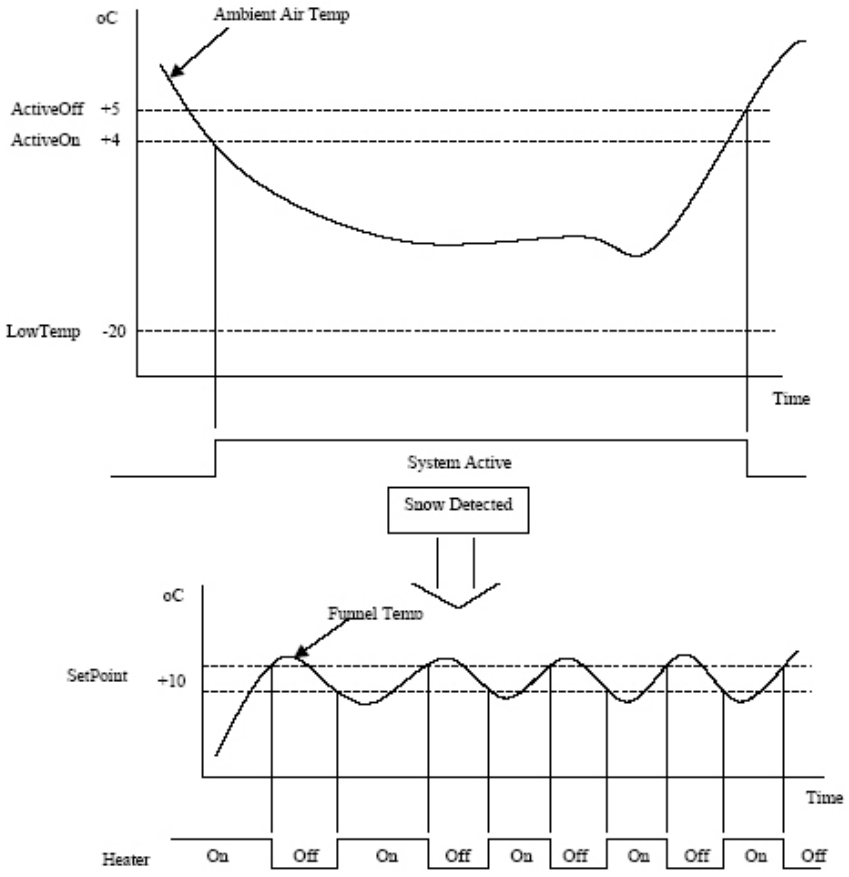

FIGURE A-2. Diagram Depicting Overall Operation

When snow is last detected, a timer is left running, to keep the heater cycling so that any snow built up on the funnel will be melted. This "Snow Run-on" timer is factory preset to 18 minutes but may be extended as required.

The heater will cycle on and off for this "Run-on" time OR while ever snow is detected (see Figure A-3).

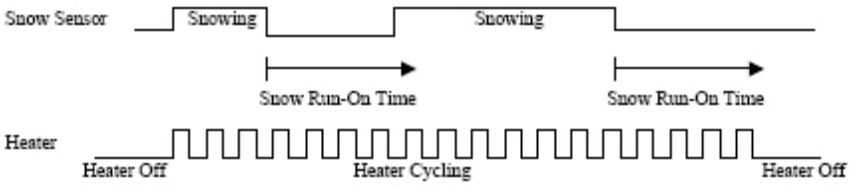

FIGURE A-3. Diagram showing how the "Snow Run-On" timer controls the heater.

A.1 High Power Operation

If the snow sensor is disabled (X22 command set to 0), the heater will cycle continually when the ambient temperature falls below the "Active On" temperature (X23 command) and is above the Low Off Temperature (X25 command). This assumes the system is active. Because this mode consumes more power, high power operation is only recommended when the CS700H uses AC power.

A.2 External Control

The CS700H is set to by default to Automatic control – where the CS700H monitors the ambient temperature and the snow sensor and operates the heater automatically. Dataloggers in weather stations that monitor the ambient temperature and the snowfall can control the tipping bucket heaters directly. Simply set the X20 command to 1 for External Control, and then use the X29 command to enable the heaters to cycle on/off (=1) or disable the cycling (=0). The ambient temperature, block temperature, snow sensor and state of the heaters can be measured using the M, R or the C command, as normal.

NOTE The Setpoint Temperature is the required temperature of the funnel – and not the block temperature read from M and the R command. The relationship between the funnel temperature, block temperature and ambient temperature has been determined through extensive testing.

There is an alternate external control mode, whereby the controlling system can actually turn the heating elements on and off. This is done using the X21 command, with heater "on" (=1) and heater "off" (=0).

CAUTION If the heating elements are left turned on, the funnel temperature may reach a point where the snow evaporates before it hits the funnel!

A.3 Status LED

The Status LED, within the ambient temperature sensor probe, flashes to indicate the mode that the CS700H is in (see Table A-2).

TABLE A-2. Status LEDs

Mode	Flash Rate	Description
Long Flash	LED on for 0.5 sec	Controller powering up.
Slow Flash	1 flash every 1.5 secs	In standby mode waiting for a heating cycle.
Medium Flash	2 flashes per second	Within a Heating Cycle and the Heating Elements are presently turned OFF. Waiting for snow to be present before turning on heaters.
Fast Flash	8 flashes per second	Within a Heating Cycle and the Heating elements are presently turned ON.

A.4 Snow Sensor

The snow sensor is actually a capacitive proximity sensor that registers any material object within a few mm range. The sensor's power is turned on and off to conserve power. Table A-3 lists the conditions in which power is applied.

The state of the snow sensor (snow detected) is read using the Measure (aM!) and Data (aD0!) commands (4th value).

NOTE The snow sensor must detect snow continuously for 5 seconds before the detected flag is set to "1". And conversely, snow must be absent for 5 seconds continuously before the detected flag is reset to "0". This process prevents a premature heating cycle when in the automatic mode.

TABLE A-3. Snow Sensor Power Options		
Mode (X20 command)	**Snow Enabled X22 command**	**Description**
Auto	0	Snow sensor doesn't have power applied. Cannot detect real snow; however it indicates snow is always present.
	1	Snow sensor only has power applied when the Ambient temperature is below the Active On temperature. Can only detect snow when temperature is in this range.
Manual	0	Snow sensor doesn't have power applied. Cannot detect real snow, however it indicates snow is always present.
	1	Snow sensor always has power applied, and can detect snow at any time.

A.5 SDI-12 Interface

You may use the SDI-12 capabilities to communicate with the microprocessor in the rain gage. This mode is enacted on each command by proceeding each SDI-12 command with an ascii '*' rather than a "break'. When the ascii '*' is detected, all of the timing/break requirements of the SDI-12 are removed.

Commands may be entered in a datalogger program or from a terminal program such as "Hyperterminal".

NOTE You must use **1200 baud, 7 bits, even parity** and no handshaking. The "**a**" is the sensor address in the displayed commands. By default, the CS700H is set to address "0".

TABLE A-4. SDI-12 V1.2 COMPLIANT COMMAND SET – Go to www.sdi-12.org		
Name	**Command**	**Response**
Break	Continuous spacing for at least 12 milliseconds	None
Acknowledge Active	a!	a<CR><LF>
Send Identification	aI!	allccccccccmmmmmmvvvxxx...xx<CR><LF> (see Note 1.)
Change Address	aAb!	b<CR><LF>
Address Query	?!	a<CR><LF>
Start Measurement	aM!	atttn<CR><LF> a0009 => (9 measurements in 0 secs)
Send Data	aD0!	(Response from Measurement and Concurrent commands; see to Note 4) a<value1><value2> ….. <value8><CR><LF> value1 = Ambient temperature (°C or °F) value2 = Block temperature (°C or °F) value3 = Units (0=°C : 1=°F) value4 = 0=no snow : 1=snow detected value5 = 0=Snow sensor disabled : 1=enabled value6 = 0=Heater Off : 1=Heater elements on value7 = 0=Automatic Control : 1=Manual Control value8 = 0=Cycle Disabled : 1=Cycle Enabled value9 = Low Power Heater cycle time left (mins)
Continuous Measurement	aR0!	Same reply as the D command
Start Verification	aV!	Atttn<CR><LF> (see Note 2)
Start Concurrent Measurement	aC!	atttnn<CR><LF> a00009 =>(9 measurements in 0 secs)

Notes:

(1) Identification has the following syntax:

a12HydrServTBHeat4.112345<CR><LF>

```
  --  ------------ --------- --- ------
| |       |          |     |    |
| |       |          |     |    ----- 5 digit Sensor ID (eg 12345)(as set in aX4 command)
| |       |          |     ---------- S/W Revision (eg 4.1)
| |       |          ----------------- Manufacturer's Model Name (TBHeat)
| |       ---------------------------- Manufacturer's ID (HydrServ)
| ----------------------------------- SDI-12 Version V1.2 Compliant
---------------------------------------- Unit Address
```

(2) The measurement command "M" and the concurrent command "C" will both return a time "ttt" of 000 indicating that the measurement will be ready in 0 seconds (immediately).

(3) With the initiate verification command (aV!), the CS700H returns a0001<CR><LF> indicating that there is 1 measurement available and it will be ready in 0 seconds. When the Data command aD0! is issued the CS700H will reply with:

a+0<CR><LF>

(4) Data Command Reply has the following syntax

0-06.5+33.3+0+1+1+0+0+0+05<CR><LF>

```
--  ----  ------  -- --  -- --  --  --  --
|    |     |   |  |  |  |  |   |   |
|    |     |   |  |  |  |  |   |   ------------ Heater Cycle Time Left
|    |     |   |  |  |  |  |   |                (5 mins in this example) (only in Automatic Control mode)
|    |     |   |  |  |  |  |   ---------------- Cycle 0=> Disabled : 1=> Enabled (only in Manual Control)
|    |     |   |  |  |  |  |                    (Only in S/W Rev 4.1 and above See X29 Command)
|    |     |   |  |  |  |  ---------------------- Control 0=> Automatic : 1=> Manual (See X20 Command)
|    |     |   |  |  |  ------------------------- Heater Elements 0=> Power Off : 1=> Power On
|    |     |   |  |  ---------------------------- Snow Sensor 0=> Disabled : 1=> Enabled (See X22 Command)
|    |     |   |  ------------------------------- Snow 0=>No Snow : 1=> Snow Detected
|    |     |   --------------------------------- Units 0=> °C : 1=> °F (See X28 Command)
|    |     ------------------------------------- Block Temperature +33.3°C
|    ------------------------------------------- Ambient Temperature –6.5°C
 ------------------------------------------------ Unit Address (0 in this example)
```

A.5.1 Special – X Commands

The SDI-12 X commands allow device specific data to be read and set. The following commands are unique to the CS700H.

NOTE In the following commands "a" is the address of the CS700H – set to "0" at the factory

TABLE A-5. Special X Commands	
User ID aX04! aX04+12345!	**– X04 Command** Get the transducer ID using the aD0! Command Set the transducer ID to 12345. Acceptable values 0-65535. This value appears in the Identify command.
External Control aX20! aX20+0! aX20+1!	**– X20 Command** Get the heater state using the aD0! Command Set the Heater Control state to 0 => Heater Elements Off Set the Heater Control state to 1 => Heater Elements On (Changing this state forces X29 Cycle Enable to 0=>disabled)
Heater Control aX21! aX21+0! aX21+1!	**– X21 Command (Only operates if "External Control" set to 1)** Get the heater state using the aD0! Command Set the Heater Control state to 0 => Heater Elements Off Set the Heater Control state to 1 => Heater Elements On (Changing this state forces X29 Cycle Enable to 0=>disabled)
Snow Sensor Enabled aX22! aX22+0! aX22+1!	**– X22 Command** Get the snow sensor enabled state using the aD0! Command Set the Snow Sensor Enable state to 0 => Snow sensor Disabled (When snow sensor is disabled, the unit reports snow as detected to force a heating cycle when the ambient is less than the active on temperature when in automatic mode) Set the Snow Sensor Enable state to 1 => Snow Sensor Enabled
ActiveOn Temperature aX23! aX23+04.0! aX23+39.2!	**– X23 Command** Get the ActiveOn temperature using the aD0! Command Set the ActiveOn temperature to +4.0°C (if X28 set to 0) Set the ActiveOn temperature to +39.2°F (if X28 set to 1)
ActiveOff Temperature aX24! aX24+05.0! aX24+41.0!	**– X25 Command** Get the LowOff temperature using the aD0! Command Set the LowOff temperature to -20.0°C (if X28 set to 0) Set the LowOff temperature to -4.0°F (if X28 set to 1)
LowOff Temperature aX25! aX25-20.0! aX25-04.0!	**– X25 Command** Get the LowOff temperature using the aD0! Command Set the LowOff temperature to -20.0°C (if X28 set to 0) Set the LowOff temperature to -4.0°F (if X28 set to 1)
SetPoint Temperature aX26! aX26+10.0! aX26+50.0!	**– X26 Command** Get the funnel SetPoint temperature using the aD0! Command Set the funnel SetPoint temperature to +10.0°C (if X28 set to 0) Set the funnel SetPoint temperature to +50.0°F (if X28 set to 1)
Snow Run-On Time aX27! aX27+18!	**– X27 Command** Get the "Snow Run-on" time after snow is detected using aD0! Set the "Snow Run-on" time to 18 mins
Celcuis / Farenheit aX28! aX28+0! aX28+1!	**– X28 Command** Get the °C / °F state using the aD0! Command Set to Celcius (data = 0) Set to Farenheit (data = 1)

Cycle Enable aX29! aX29+0! aX29+1!	**– X29 Command (Only operates if "External Control" set to 1)** Get the Cycle Enable state using the aD0! Command Set the Cycle Enable state to 0 => Heating Cycle Off Set the Cycle Enable state to 1 => Heating Cycle On (Changing this state forces X21 Heater Control to 0=> Off) (This command is only available in S/W Rev 4.1 and above)
Preset / Calibrate Ambient Temperature Sensor aX91! aX91+22.3! aX91+72.1!	**– X91 Command** Get the Ambient temperature sensor using the aD0! Command Set the Ambient temperature sensor to +22.3°C (if X28 set to 0) Set the Ambient temperature sensor to +72.1°F (if X28 set to 1)
Preset / Calibrate Funnel Temperature Sensor aX92! aX92+18.6! aX92+65.5!	**– X92 Command** Get the Funnel temperature sensor using the aD0! Command Set the Funnel temperature sensor to +18.6°C (if X28 set to 0) Set the Funnel temperature sensor to +65.5°F (if X28 set to 1)
Set Factory Defaults aX99+1!	**– X99 Command** Set the factory defaults (only when data is +1)

A.5.2 Operating Modes

The CS700H can be put into Automatic or Manual Operation Modes. Table A-6 describes how the modes are entered and the operation of the modes.

TABLE A-6. Operating Modes

Auto/ Manual X20	Cycle Enable X29	Heater On/Off X21	Snow Enabled X22	Snow	Description
0	X	X	1	0 / 1	Auto Mode : When the Ambient temperature falls below the Active On temperature X23, and Snow is detected, then a Heating Cycle is started. (That is, the heater elements are switched on and off to keep inside the funnel at the SetPoint temperature X26.) This is a low power mode, as the heater cycle only begins when snow is detected !
0	X	X	0	1	Auto Mode : Same as above, but because the snow sensor is disabled the snow detected flag is always set. The Heating Cycle is started when the Ambient temperature fall below the Active On temperature X23. This mode uses more power and should only be used when the system is supplied by mains power.
1	0 / 1	0	X	X	Manual Mode : The Cycle Enable flag X29 is used to force a Heating Cycle. This is set or cleared by another system at the site – as it determines whether heating is required. When the Cycle Enable flag is “0” the heaters are off. When the Cycle Enable flag is “1” then the Heating Cycle is started. (That is, the heater elements are switched on and off to keep inside the funnel at the SetPoint temperature X26.) The snow sensor state can be read using the measure/data commands, but its state is ignored when controlling the heaters.
1	0	0 / 1	X	X	Manual Mode : The heater elements can be controlled directly with the Heater On/Off flag X21. When the flag is “0” the heaters are off, and when the flag is “1” the heaters are on. Note that the heaters must be cycled by the controlling system in order to control the funnel temperature. This mode must be used with caution !

(X = Don’t Care)

A.5.3 Command Examples

For the following examples, the SDI-12 address is set to "0".

NOTE <CR> = Carriage Return and <LF> = Line Feed

A.5.3.1 Proving Communications is working

Type *0! and you should get a "0 <CR> <LF>" reply, indicating that communications is operating correctly.

A.5.3.2 Taking a Measurement

Type *0M! and you will get "00009 <CR> <LF>" reply indicating there are nine measurements ready in 0 secs

Type *0D0! and you will get "0+03.5+14.2+0+1+1+1+0+0+00 <CR> <LF>" reply with the parameters "addr AmbientT BlockT Units Snow SnowEn Heater ExtCtrl CycEn TimeLeft"

Refer to Table A-4 for details on these parameters.

A.5.3.3 Example of Manual Mode Operation

Type *0X20+1! to enter manual mode and you will get a "00001<CR><LF>" reply indicating there is 1 data value ready in 0 secs.

Type *0X29+1! to start a heating cycle and you will get a "00001<CR><LF>" reply indicating there is 1 data value ready in 0 secs. The heaters will start cycling on and off to keep inside the funnel at the Setpoint temperature X26. The status LED will flash medium (2 flashes/sec) when the heater elements are off and flash fast (8 flashes/sec) when the heater elements are on.

Type *0X29+0! To stop a heating cycle and you will get a "00001<CR><LF>" reply indicating there is 1 data value ready in 0 secs. The heaters will turn off and the status LED will slow flash (1 flash every 1.5 secs).

Refer to Table A-4 for details of other commands.

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