

***SBS500 & SBS500H
Tipping Bucket
Raingauge***

User Guide

Issued 2.11.10

Campbell Scientific Ltd. acknowledges the technical expertise provided by Environmental Measurements Ltd. in their SBS500 Manual, on which this User Guide is based.

Copyright © 2003 Campbell Scientific Ltd.

Guarantee

This equipment is guaranteed against defects in materials and workmanship. This guarantee applies for twelve months from date of delivery. We will repair or replace products which prove to be defective during the guarantee period provided they are returned to us prepaid. The guarantee will not apply to:

- Equipment which has been modified or altered in any way without the written permission of Campbell Scientific
- Batteries
- Any product which has been subjected to misuse, neglect, acts of God or damage in transit.

Campbell Scientific will return guaranteed equipment by surface carrier prepaid. Campbell Scientific will not reimburse the claimant for costs incurred in removing and/or reinstalling equipment. This guarantee and the Company's obligation thereunder is in lieu of all other guarantees, expressed or implied, including those of suitability and fitness for a particular purpose. Campbell Scientific is not liable for consequential damage.

Please inform us before returning equipment and obtain a Repair Reference Number whether the repair is under guarantee or not. Please state the faults as clearly as possible, and if the product is out of the guarantee period it should be accompanied by a purchase order. Quotations for repairs can be given on request. It is the policy of Campbell Scientific to protect the health of its employees and provide a safe working environment, in support of this policy a "Declaration of Hazardous Material and Decontamination" form will be issued for completion.

When returning equipment, the Repair Reference Number must be clearly marked on the outside of the package. Complete the "Declaration of Hazardous Material and Decontamination" form and ensure a completed copy is returned with your goods. Please note your Repair may not be processed if you do not include a copy of this form and Campbell Scientific Ltd reserves the right to return goods at the customers' expense.

Note that goods sent air freight are subject to Customs clearance fees which Campbell Scientific will charge to customers. In many cases, these charges are greater than the cost of the repair.



Campbell Scientific Ltd,
Campbell Park, 80 Hathern Road,
Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141
Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

PLEASE READ FIRST

About this manual

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

Some useful conversion factors:

Area: 1 in ² (square inch) = 645 mm ²	Mass: 1 oz. (ounce) = 28.35 g 1 lb (pound weight) = 0.454 kg
Length: 1 in. (inch) = 25.4 mm 1 ft (foot) = 304.8 mm 1 yard = 0.914 m 1 mile = 1.609 km	Pressure: 1 psi (lb/in ²) = 68.95 mb Volume: 1 UK pint = 568.3 ml 1 UK gallon = 4.546 litres 1 US gallon = 3.785 litres

In addition, while most of the information in the manual is correct for all countries, certain information is specific to the North American market and so may not be applicable to European users.

Differences include the U.S standard external power supply details where some information (for example the AC transformer input voltage) will not be applicable for British/European use. *Please note, however, that when a power supply adapter is ordered it will be suitable for use in your country.*

Reference to some radio transmitters, digital cell phones and aerials may also not be applicable according to your locality.

Some brackets, shields and enclosure options, including wiring, are not sold as standard items in the European market; in some cases alternatives are offered. Details of the alternatives will be covered in separate manuals.

Part numbers prefixed with a “#” symbol are special order parts for use with non-EU variants or for special installations. Please quote the full part number with the # when ordering.

Recycling information



At the end of this product's life it should not be put in commercial or domestic refuse but sent for recycling. Any batteries contained within the product or used during the products life should be removed from the product and also be sent to an appropriate recycling facility.

Campbell Scientific Ltd can advise on the recycling of the equipment and in some cases arrange collection and the correct disposal of it, although charges may apply for some items or territories.

For further advice or support, please contact Campbell Scientific Ltd, or your local agent.



Campbell Scientific Ltd, Campbell Park, 80 Hathern Road, Shepshed, Loughborough, LE12 9GX, UK
Tel: +44 (0) 1509 601141 Fax: +44 (0) 1509 601091
Email: support@campbellsci.co.uk
www.campbellsci.co.uk

Contents

1. General Description	1
2. Technical Specifications.....	2
3. Operation.....	2
4. Installation and Siting	3
4.1 Choosing a Site.....	3
4.2 Unpacking.....	4
4.3 Mounting	4
4.4 Levelling.....	4
5. Wiring	5
6. Datalogger Programming	5
6.1 Pulse Channel Example Programs.....	6
6.1.1 CR1000 Example Program.....	6
6.1.2 CR200(X) Series Example Program.....	7
6.1.3 CR10X Example Program	7
6.2 Control Port Example	8
6.2.1 CR1000 Example Program.....	8
6.2.2 CR10X Example Program	9
7. Maintenance.....	10
8. Calibration.....	11
8.1 Static Adjustment and Calibration.....	11
8.2 Dynamic Calibration.....	12
8.3 Calculating the Calibration Factor.....	13
9. SBS500H Heated Version	14
9.1 Operation of Heating Circuit	15
10. Advantages and Limitations of a Tipping Bucket Gauge.....	17

Figures

1. SBS500 Series Raingauge	1
2. Filter Unit	2
3. Nozzle.....	2
4. Internal View of SBS500H (Heated Version)	3
5. Levelling the SBS500/SBS500H using a Spirit Level	5
6. Wiring Diagram for SBS500/SBS500H	5
7. Setup for Static Calibration	11
8a. Dynamic Calibration using a Measured Quantity of Water.....	12
8b. Dynamic Calibration using the Constant Head Method	13
9. Heater Elements.....	15
10. 12V Heater System Wiring.....	16
11. 24V Heater System Wiring.....	16

Tables

1. Calibration Factors	13
------------------------------	----

SBS500/SBS500H Raingauge

The SBS500 and SBS500H are well-designed tipping bucket raingauges which combine durable construction with reasonable cost. The gauge offers less resistance to air flow than most previous designs, which helps to reduce the sampling errors that inevitably occur during wind-driven rain, and the SBS series as a whole has less susceptibility to 'splash-out' errors. The gauge is manufactured for Campbell Scientific by Environmental Measurements Ltd. and, owing to its rugged aluminium construction, when correctly sited will provide many years of reliable operation in the most rigorous of environmental conditions. The SBS500H is a heated version of the SBS500. A larger version of the gauge (model SBS1000/SBS1000H), which has a higher resolution, is available to special order.

1. General Description

The information in this manual applies to both the SBS500 and the SBS500H, except for section 7 which includes additional information applicable to the SBS500H heated version only.

The main collector body of the raingauge is constructed from 2mm thick powder coated aluminium, giving strength and rigidity. The base section is manufactured from LM6 marine grade aluminium. The base includes three adjustable mounting feet and a bubble level gauge for free-standing applications, or the feet can be removed and the unit bolted firmly to a suitable mounting plinth or concrete slab for more permanent applications.



Figure 1 SBS500 Series Raingauge

2. Technical Specifications

Please note that models SBS1000 and SBS1000H are available to special order only.

Funnel rim height:	440mm
Collector area (SBS500):	500cm ²
(SBS1000):	1000cm ²
Tip sensitivity:	0.2mm of rain per tip (SBS500) 0.1mm of rain per tip (SBS1000)
Output:	Contact closure – two reed switches allowing monitoring to be carried out on an additional channel. Reed contact rating: 50W (DC resistive) Reed supply voltage: 100V DC maximum
Weight (approx.):	6Kg.

Heater Specifications (model SBS500H):

Supply current: 12V supply: Heaters off – 12mA typ., Heaters on – 2.2A typ.
24V supply: Heaters off – 15mA typ., Heaters on – 1.1A typ.
Heaters are activated when internal enclosure temperature falls to 1°C and are deactivated when temperature rises to approx. 4°C.

3. Operation

The tipping bucket arrangement is similar to most other gauges of this type; precipitation is collected by the funnel and flows through a stainless steel gauze filter which traps and removes any leaves, etc. Water then passes through a nozzle into one of the two buckets situated at either end of a short balance arm. See illustrations below – see Figures 2 and 3.

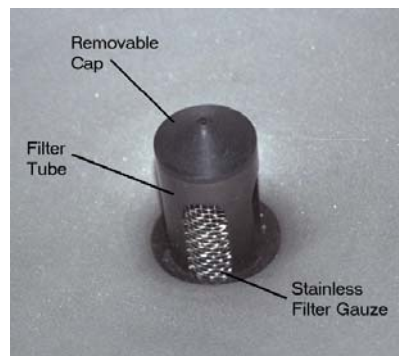


Figure 2 Filter Unit



Figure 3 Nozzle

The balance arm and bucket assembly rotates around precision rolling pivot bearings. The arm tips when the first bucket is full, emptying this bucket and positioning the second under the funnel. The tipping process repeats indefinitely as long as rain continues to fall, with each tip corresponding to a fixed quantity of rainfall. At each tip, the moving balance arm forces a magnet to pass a reed switch, causing contact to be made for a few milliseconds. A two-core cable is used to connect the gauge to the datalogger where the switch closures are counted. This mechanism is shown in Figure 4. The water is normally drained away through outlets, but adapters can be fitted if water retention is required.



Figure 4 Internal View of SBS500H (Heated Version)

The SBS500/SBS500H is adjusted at manufacture to tip once for each 0.2mm of rain (a sensitivity of 0.25mm/tip is optional). More information on gauge calibration is given in Section 8.

4. Installation and Siting

4.1 Choosing a Site

The site for a raingauge is often a compromise between optimum exposure and operational constraints. The optimum site is level ground with a uniform scattering of objects in the surrounding area, thus reducing overall wind speeds. However, these objects should not be large enough to cause eddy currents or high gust speeds to occur near to the gauge, or so close to the gauge that rain is prevented from entering the funnel. Site the gauge carefully, and try to avoid obvious sources of error, such as nearby trees or buildings or other obstructions.

A useful 'rule of thumb' is that the distance between the gauge and any obstruction should be at least as great as twice the height of the obstruction above the ground. For standard meteorological sites in the UK, the Meteorological Office specify the height at which the rim of a raingauge should be above a short grass surface, and the SBS500/SBS500H should be exposed similarly if measurements are required for comparison with those from agrometeorological or synoptic sites.

NOTE

No two raingauge designs are ever likely to produce identical results, and identical raingauges can give slightly different catches even when sited within a metre of each other.

Research has shown that a raingauge obstructs the flow of air and that the flow accelerates and turbulence increases over the top of the funnel. This can cause less rain to be collected in the funnel than otherwise would have fallen on the ground.

The body of the SBS500/SBS500H has a profile which has been designed to reduce drag and turbulence using extensive practical data collected by Dr. Ian Strangeways (Strangeways, 1996) and it can therefore be sited conventionally on exposed sites with some confidence. Further details on the exposure of raingauges are given in HMSO (1956, 1982) and by Rodda (1967). Another useful text on exposure and associated errors is Painter (1976).

NOTE If the gauge is sited in the area of livestock, then fencing will almost always be required to prevent damage from (and to) the animals.

4.2 Unpacking

Unpack the SBS500/SBS500H carefully. The tipping mechanism is immobilised before shipping to prevent damage in transit. To release the mechanism:

1. Remove the funnel of the gauge from its base by unscrewing the three screws and lifting the funnel.
2. Remove the piece of foam from under the bucket mechanism. Check the bucket mechanism for freedom of movement. The foam may be saved for use whenever the raingauge is transported.

4.3 Mounting

The SBS500/SBS500H weighs 6kg, and so is heavy enough that it can, in many cases, be simply placed on an appropriate flat surface, ready for use.

However, three holes adjacent to the levelling feet are provided so that steel pegs (also provided) can be fitted for extra security in softer ground. In areas of high winds, or where additional security is required, these holes can be used to bolt the gauge (after correct levelling) to a solid surface, such as a concrete slab, using appropriate anchor bolts – see Figure 3 which shows these extra bolts.

4.4 Levelling

If the raingauge is tilted by more than a few degrees, the bucket mechanism may be thrown out of balance, significantly affecting its calibration. Furthermore, during wind-driven rain the response of a gauge with a tilted funnel collector will vary with wind direction. It is therefore important to ensure that the rim of the raingauge funnel is precisely levelled, using a spirit level.

Although a small circular bubble-type spirit level is incorporated into the base assembly of the raingauge, this is provided only as a ‘quick check’ for initial setting up. Always level the rim precisely, using a separate spirit level (see Figure 5) and check regularly. Level the gauge by slackening the locking nuts on the adjustable feet, adjust the feet to achieve a perfectly level rim, and retighten the locknuts. If required, fit the pegs through the holes provided next to the adjusters.

NOTE Accurate and precise levelling of the raingauge, as described above, using a spirit level, is the simplest and most effective way to ensure accurate rainfall measurements.

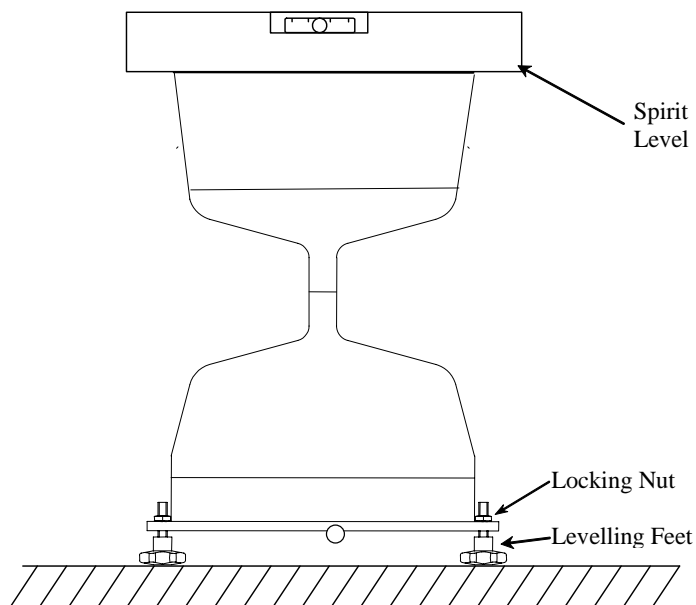


Figure 5 Levelling the SBS500/SBS500H using a Spirit Level

5. Wiring

The rain gauge is supplied with a 6m cable which may be extended if required. For most applications the SBS500/SBS500H may be connected directly to a pulse counting input on the datalogger as shown in Figure 6. For a long cable, a significant capacitance can exist between the conductors, which discharges across the reed switch as it closes. As well as shortening the life of the switch, a voltage transient may be induced in any other wires which run close to the rain gauge cable each time the gauge tips. A 100Ω resistor is fitted inside the gauge to protect the switch from arcing and prevent transients.

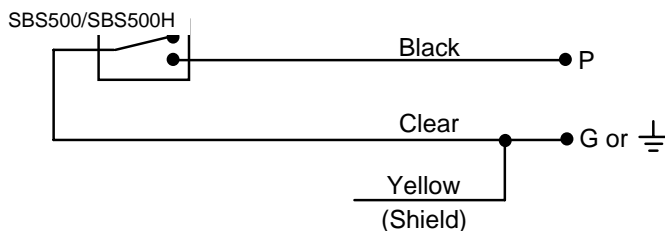


Figure 6 Wiring Diagram for SBS500/SBS500H

6. Datalogger Programming

NOTE

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

Precipitation is measured using a Pulse Count with a switch closure configuration code. The multiplier used in the Pulse Count instruction determines the units in which rainfall is reported.

The sensitivity of the SBS500/SBS500H is set at manufacture to a nominal figure of 0.2 mm/tip and each gauge is subsequently calibrated as described in Section 8.1. For precise measurements, use this calibration value in your program instead of the nominal 0.2 mm multiplier.

6.1 Pulse Channel Example Programs

The following example programs use a pulse channel to read the output from the precipitation gauge. The CR1000 example will also work with the CR800, CR850, CR3000, and CR5000. CR9000(X) programming is similar to the CR1000 except it has an additional parameter in the PulseCount instruction to specify the pulse module's slot.

The CR10X program will also work with the CR500, CR510, CR10, 21X or CR23X. CR7 programming is similar to the CR10X but has an additional parameter in the PulseCount instruction to specify the slot that the Pulse Card is in.

6.1.1 CR1000 Example Program

```
'CR1000

'SBS500 Tipping Blk > P1
'                               Clr > ground
'Declare 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

BeginProg
    Scan(1,Sec,1,0)
        PulseCount(Rain_mm,1,1,2,0,0.2,0)
        CallTable(Rain)
    NextScan
EndProg
```

6.1.2 CR200(X) Series Example Program

```
'CR200(X) Series

'SBS500 Tipping Blk > P_SW
'                               Clr > ground

'Declare 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)

    'SBS500 Rain Gauge measurement Rain_mm:
    PulseCount(Rain_mm,P_SW,2,0,0.2,0)

    'Call Data Tables and Store Data
    CallTable(Rain)
    NextScan
EndProg
```

6.1.3 CR10X Example Program

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

1: Pulse (P3)
1: 1           Reps
2: 1           Pulse Channel 1
3: 2           Switch Closure, All Counts
4: 3           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: 3      Loc [ Rain_mm ]

*Table 2 Program
01: 0      Execution Interval (seconds)

*Table 3 Subroutines

End Program

```

6.2 Control Port Example

The following example programs use a control port to read the output from the precipitation gauge. The CR1000 example will also work with the CR800, CR850, and CR3000. The CR10X program will also work with the CR500, CR510, or CR23X.

6.2.1 CR1000 Example Program

```

'CR1000

'SBS500 Tipping Blk > C4
'                               Clr > 5v

'Declare Variables and Units
Public BattV
Public Rain_mm

Units BattV = Volts
Units Rain_mm =mm

DataTable(OneMin,True,-1)
  DataInterval(0,1,Min,10)
  Totalize (1,Rain_mm,FP2,False)
EndTable

'Define Data Tables
DataTable(OneDay,True,-1)
DataInterval(0,1440,Min,10)
  Minimum(1,BattV,FP2,False,False)
  Totalize (1,Rain_mm,FP2,False)           'SBS500 tipping bucket
EndTable

'Main Program
BeginProg
  Scan(5,Sec,1,0)
  'Default Datalogger Battery Voltage measurement BattV
  PanelTemp (PTemp,_50Hz)
  Battery(BattV)

  'SBS500 Heated Rain Gauge measurement Rain_mm
  PulseCount(Rain_mm,1,14,2,0,0.2,0)

'Call Data Tables and Store Data
CallTable(OneMin)

```



```

CallTable(OneDay)
NextScan
EndProg

```

6.2.2 CR10X Example Program

```

;{CR10X}
;
*Table 1 Program
01: 1      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: 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.

7. Maintenance

To ensure reliable and accurate measurements, we recommend that the following checks be carried out every month if possible.

NOTE

If the gauge is connected to an operating datalogger you should try to avoid manually tipping the buckets during maintenance unless doing the balance check described in Item 5a, below.

1. Inspect the funnel for any damage or blockage and check the integrity of the connecting cable. At certain times of the year, leaves may accumulate in the bottom of the funnel, clogging the filter and preventing water flow to the buckets beneath, or reducing the flow rate to a slow drip. Remove the funnel from the base and clear any leaves or debris.
2. Clean the filter as follows:
 - a) Unscrew the end cap from the filter tube.
 - b) Carefully remove the stainless steel filter gauze and clean.
 - c) Replace the filter and re-fit and replace the filter cap.
3. Check that the gauge is still level. It is surprisingly easy for an apparently immovable gauge to become tilted as a result of small ground movements, vandalism or just inquisitive fingers.
4. Remove any dirt from, and clean, the bucket, being careful not to tip the bucket if the gauge is still transmitting to the datalogger. If you want to check that the balance arm/bucket assembly is free to move, see Items 5a and 5b, below.

Checking the Balance Arm Assembly with an Active Datalogger Link

- 5a. If the datalogger is still active and logging data, you can still check that the balance arm is free to move. This can be done by slowly pouring a measured quantity of water (say 250cm³) through the gauge and counting the tips. It is worthwhile carrying this out at regular weekly intervals (for example, every Monday at 0900) while leaving the gauge connected to the datalogger. Providing a significant volume of water is used, these weekly checks can easily be identified in the logged measurements. This simple procedure confirms that the gauge is functioning, detects any marked change in the calibration and (if carried out punctually) introduces an independent time check into the records.

Checking the Balance Arm with an Inactive Datalogger Link

- 5b. If the datalogger is disconnected or not logging data, it is a good idea to check the balance arm for stiffness. The simplest way to do this in the field is to attempt to balance the bucket in its centre position. It should be very difficult (if not impossible) to do this. If the bucket balances easily, then examine the assembly for any dirt or wear on the pivot pin and bucket tubes.

A spares kit is available, comprising filter, filter cap etc. Please contact Campbell Scientific for spare parts requirements.

8. Calibration

The sensitivity of the SBS500/SBS500H is set at manufacture to a nominal figure of 0.2mm/tip (optionally 0.25mm/tip) and each gauge is subsequently calibrated as described in Section 8.1. The calibration factor is given on a certificate at the end of this manual and is also recorded on a label inside the rain gauge. For precise measurements use this calibration value in your program instead of the nominal value of 0.2 shown in the program fragment in Section 6, above. Update this figure if the value changes on recalibration.

Before any re-calibration is undertaken, take the opportunity to check and carry out any maintenance that may be required.

8.1 Static Adjustment and Calibration

The following procedure is carried out during manufacture and may be repeated if the calibration appears to have shifted.

1. Install the gauge over a sink unit as illustrated in Figure 7, ensuring that it is correctly levelled.

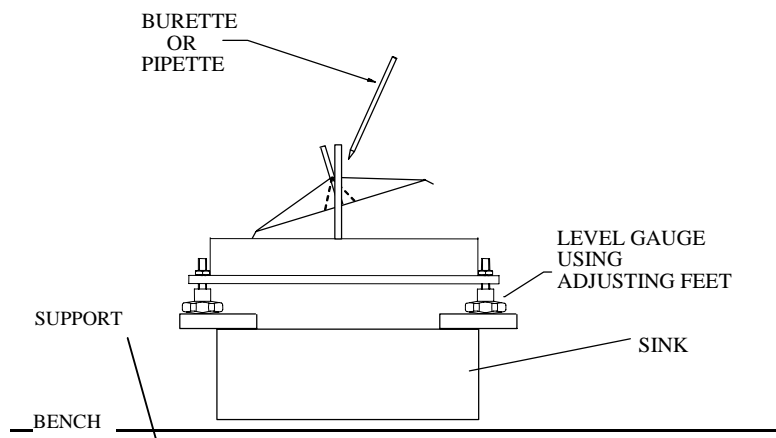


Figure 7 Setup for Static Calibration

2. Using a burette or pipette, slowly drip in 10cm³ of water (for the 0.2mm/tip gauge) into one side of the bucket. The bucket should tip on the last drip of water. Adjust the relevant calibration screw, situated under the tipping bucket, until this condition is met. Repeat for the other side of the bucket.

It may not be possible to set the screws very precisely using this method, but it should be done with as much care as possible. It is obviously very important to ensure that both buckets tip in response to the same amount of water. Many manufacturers and users of tipping bucket gauges aim to adjust the bucket settings until exactly the correct calibration is achieved. However, a dynamic test (see below) is required to check this calibration precisely after each readjustment and the process becomes very time-consuming. In any case, it is virtually impossible to get the adjustments absolutely correct, and it is generally preferable to adjust the settings as closely as is reasonably practical, and then to derive a calibration factor for each gauge individually after a dynamic calibration.

8.2 Dynamic Calibration

The SBS500/SBS500H can be calibrated dynamically in two ways – by using a measured quantity of water or, preferably, by using the ‘constant head’ method. These two methodologies are described below.

1. Set up the gauge as illustrated in Figure 8a or Figure 8b, carefully levelled and connected to the datalogger.

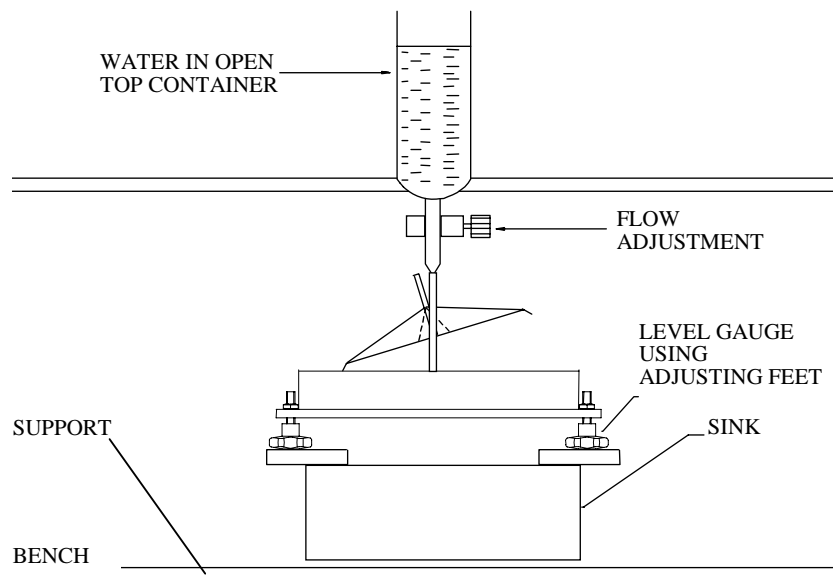


Figure 8a Dynamic Calibration using a Measured Quantity of Water

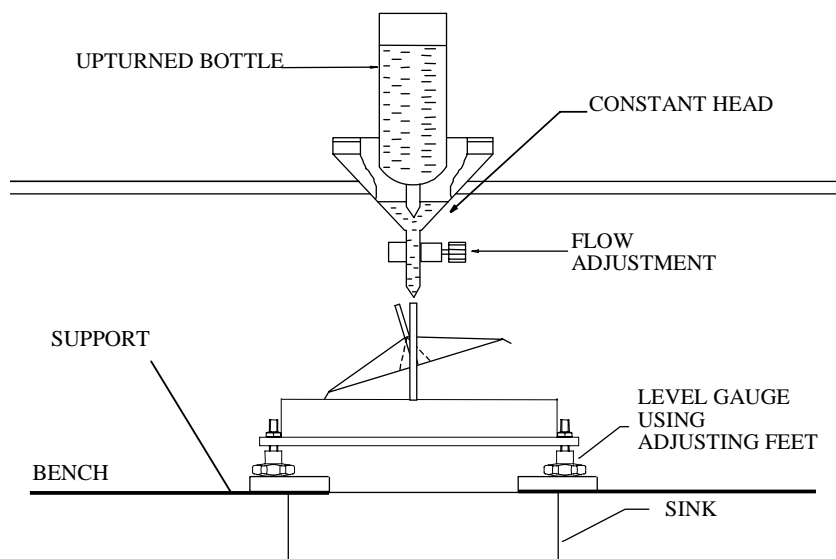


Figure 8b Dynamic Calibration using the Constant Head Method

2. Fill the water container with 1000cm³ of water for a 0.2mm calibration. This is usually achieved most precisely and consistently by weighing the water on a balance capable of measuring to 0.1g (0.1cm³). An alternative is to use a good quality graduated measuring cylinder.
3. Allow the water to drip slowly into the gauge, allowing at least 60 minutes for the container to empty (approximately 40 seconds for each tip). This is a rate equivalent to a rainfall of 10mm/hour, as recommended in BS7843 Section 2.1 for calibration purposes. At the end of this period approximately 100 tips will have occurred. The exact number is obtained from the datalogger, together with an estimation of what fraction of a 'tip' is left in whichever bucket is still filling as the flow of water finishes. This fraction can either be assessed visually, or, for a more exact estimate, a graduated syringe can be used.

8.3 Calculating the Calibration Factor

Using the figures from the dynamic calibration tables, the calibration factor can be read from Table 1.

Table 1 Calibration Factors	
Number of Tips	Calibration Factor
97.8 to 98.2	0.204mm/tip
98.3 to 98.7	0.203mm/tip
98.8 to 99.2	0.202mm/tip
99.3 to 99.7	0.201mm/tip
99.8 to 100.2	0.200mm/tip
100.3 to 100.7	0.199mm/tip
100.8 to 101.2	0.198mm/tip
101.3 to 101.7	0.197mm/tip

Alternatively, the calibration factor can be calculated using the formula shown below:

The nominal number of tips for a 0.2mm bucket is 100.

Let N equal the *actual* number of tips plus the fractional part left in the one bucket.

The calibration factor (CF) is then:

$$CF = 0.2 \text{ (optionally } 0.25) \times 80/N$$

For example, if $N = 78.8$, then:

$$\begin{aligned} CF &= 0.2 \text{ (optionally } 0.25) \times 80/78.8 \\ &= 0.203\text{mm/tip} \end{aligned}$$

In other words, each tip corresponds to 0.203mm of rainfall. Provided that CF lies between 0.197 and 0.204mm, it will be acceptable for most purposes. If the CF lies outside these limits, repeat the static and dynamic calibration procedures.

The amount of rainfall in any particular interval is obtained by multiplying the number of recorded tips by the calibration factor.

This type of dynamic calibration gives repeatable results indoors, but it is not a true representation of the gauge's sensitivity to natural precipitation. Useful results can be obtained by comparing the output from the SBS500/SBS500H with the catches from a standard 'Snowdon pattern' gauge (HMSO, 1956) sited nearby.

Care should be taken when studying such comparisons, however, as even two identical raingauges can give different readings if spaced a few metres apart.

As discussed above, the design of the gauge and its exposure are important factors. The aerodynamic design of the SBS series of raingauges should produce readings close to the true precipitation on the ground, in a wider range of weather conditions, than conventional raingauges (even 'standard' designs such as the 'Snowdon' gauge). For sites with poor exposure characteristics, comparison of different types of gauges may vary with weather conditions.

9. SBS500H Heated Version

The following describes the additional parts for the heated version of the raingauge. See Figure 4 for an internal view of the SBS500H, showing the heaters, control unit and terminals.

The heating system is designed to prevent the bucket assembly and pivot freezing and icing up in cold temperatures, and to return the raingauge to full operation as quickly as possible. It consists of:

- 1) Two series of heater elements.
- 2) An electronic sensor.
- 3) The heater control unit.

NOTE

The heating system is not designed to melt heavy accumulations of snow, although any snow that does melt within the funnel assembly will be recorded as precipitation.

9.1 Operation of Heating Circuit

A separate power supply must be connected to the heating system before it will function. The supply must be capable of providing a current of 2.2A from a 12V system, or 1.1A from a 24V system. Such a supply should normally be independent of the datalogger power supply. A Campbell Scientific Power Supply unit such as PS100E-LA, BP17E-LA or BP24E-LA, are not rated to provide the required current.

The heaters require a direct current (DC) supply. When attaching a power cable to the heater connections, either use a separate cable from the signal cable, or use a cable with individually screened pairs to avoid inducing false readings when the heater turns on and off.

When power is connected, the temperature is controlled automatically. The temperature sensor, mounted above the tipping bucket, monitors the air temperature within the raingauge.

The controller automatically activates the heaters when the temperature inside the raingauge enclosure drops to 1°C. The heaters will remain on until the temperature inside the enclosure reaches 4°C.

The heaters consist of six wire-wound ceramic resistors as shown in Figure 9. They are arranged in two blocks of three resistors.



Figure 9 Heater Elements

The heaters operate from a 12V supply. A 24V version is available to special order. The appropriate schematic wiring diagrams, showing links for the 12V and 24V versions, are shown below.

CAUTION

Ensure that you use the appropriate configuration and set the link(s) for 12V or 24V input supply to suit your heater control unit.

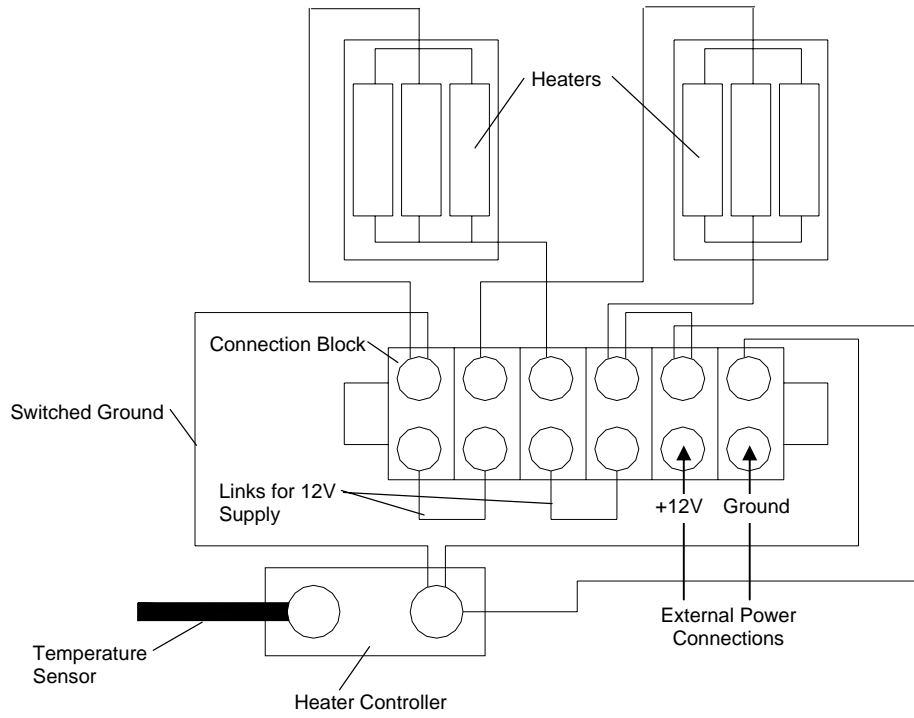


Figure 10 12V Heater System Wiring

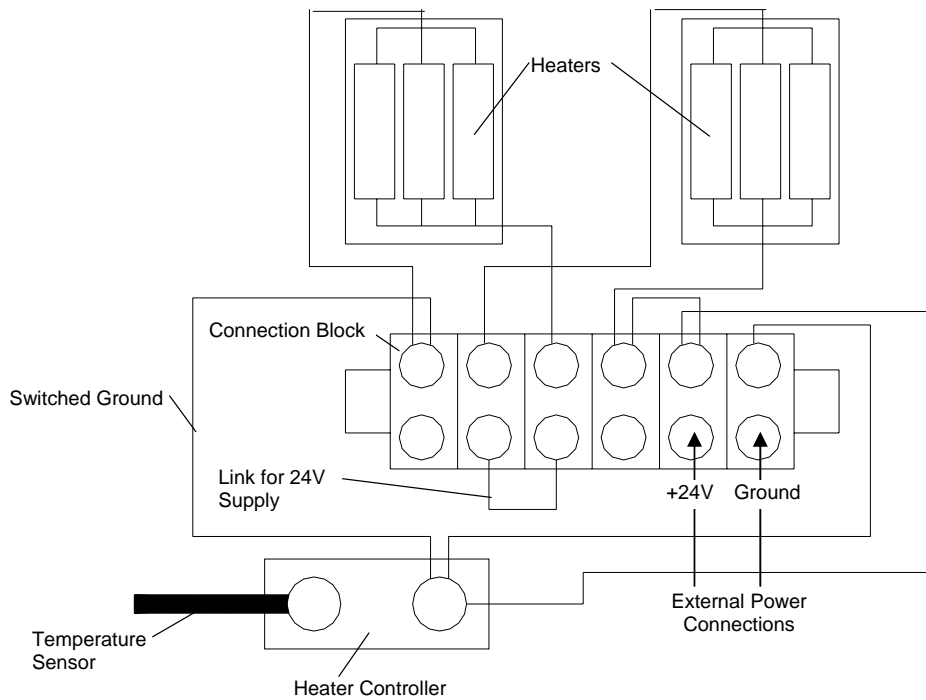


Figure 11 24V Heater System Wiring

10. Advantages and Limitations of a Tipping Bucket Gauge

Gauges which operate on the tipping bucket principle provide a digital output, which simplifies connection to a datalogger. The pulses returned during rainfall may be counted over any time interval desired allowing accurate determination of the rainfall rate (this variable, sometimes called 'intensity', is frequently used in soil erosion studies and is relevant to some aspects of crop pathology).

A tipping bucket gauge responds to discrete quanta of rainfall, and the accuracy and reproducibility of this quantum are determined not only by factors such as friction in the bearings, etc. but also by the rate of fill of the buckets. When the rainfall rate is high, a bucket may *start* to tip when the necessary volume of water has been collected, but while the bucket is moving away from the funnel outlet, an extra volume will have been collected and lost through spillage. The resulting degradation in accuracy is of the order of 4% at rainfall rates of 25mm/hr and 8% at 133mm/hr for most gauges (Parkin et al, 1982). This is important when results from gauges of different designs are compared. These errors worsen when gauge sensitivity is increased. It follows that gauge design is always a compromise between the need for good resolution and good overall accuracy in rainfall totals.

References

HMSO (1956) *Handbook of Meteorological Instruments*, Part 1, Met.0. 577.

HMSO (1982) *Observers Handbook*, Met.0. 933.

Painter, R.D. (1976) in *Methods of Plant Ecology* pp 369-410. Ed. by S.B.Chapman, Blackwell Scientific Press, Oxford

Parkin, D.A., King, W.D. and Shaw, D.E. (1982) *An automatic raingauge network for a cloud seeding experiment* J.Appl.Meteorol. p 228.

Rodda, J.C., (1967) *The rainfall measurement problem* Proc. IAHS Gen. Ass. Bern, IAHS Pub. No. 78, 215-231

Strangeways, I.C. (1996) *Back to Basics: The 'Met Enclosure': Part 2(b) – Raingauges, their errors*. Weather, 51, pp. 298-303.

SBS500 Series Tipping Bucket Raingauge

The serial number and calibration factor for this gauge are as follows:
(these are also recorded on a label inside the gauge)

Serial No. _____

Calibration Factor: _____

Date: _____



Shepshed, Loughborough, LE12 9GX, UK

Tel: +44 (0) 1509 601141

Fax: +44 (0) 1509 601091

Email: support@campbellsci.co.uk

www.campbellsci.co.uk

Company Registration Number: 1933935

VAT No. GB 428 4539 33

CAMPBELL SCIENTIFIC COMPANIES

Campbell Scientific, Inc. (CSI)

815 West 1800 North
Logan, Utah 84321
UNITED STATES

www.campbellsci.com • info@campbellsci.com

Campbell Scientific Africa Pty. Ltd. (CSAf)

PO Box 2450
Somerset West 7129
SOUTH AFRICA

www.csafrica.co.za • sales@csafrica.co.za

Campbell Scientific Australia Pty. Ltd. (CSA)

PO Box 444
Thuringowa Central
QLD 4812 AUSTRALIA

www.campbellsci.com.au • info@campbellsci.com.au

Campbell Scientific do Brazil Ltda. (CSB)

Rua Luisa Crapsi Orsi, 15 Butantã
CEP: 005543-000 São Paulo SP BRAZIL

www.campbellsci.com.br • suporte@campbellsci.com.br

Campbell Scientific Canada Corp. (CSC)

11564 - 149th Street NW
Edmonton, Alberta T5M 1W7
CANADA

www.campbellsci.ca • dataloggers@campbellsci.ca

Campbell Scientific Centro Caribe S.A. (CSCC)

300N Cementerio, Edificio Breller
Santo Domingo, Heredia 40305
COSTA RICA

www.campbellsci.cc • info@campbellsci.cc

Campbell Scientific Ltd. (CSL)

Campbell Park
80 Hathern Road
Shepshed, Loughborough LE12 9GX
UNITED KINGDOM

www.campbellsci.co.uk • sales@campbellsci.co.uk

Campbell Scientific Ltd. (France)

3 Avenue de la Division Leclerc
92160 ANTONY
FRANCE

www.campbellsci.fr • info@campbellsci.fr

Campbell Scientific Spain, S. L.

Avda. Pompeu Fabra 7-9
Local 1 - 08024 BARCELONA
SPAIN

www.campbellsci.es • info@campbellsci.es

Campbell Scientific Ltd. (Germany)

Fahrenheitstrasse13, D-28359 Bremen
GERMANY

www.campbellsci.de • info@campbellsci.de