SR50 SONIC RANGING SENSOR
OPERATOR'S MANUAL

REVISION: 3/03

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CAUTIONARY NOTES

1.   The order in which the connections are made is critical. Always connect Ground first, followed by +12V and then the remaining SDI-12/Data Bus, Sensor Enable Line and Shield. When disconnecting the sensor, the reverse order should be followed.

2.   Before disassembling the transducer assembly, refer to "Assembly/Disassembly Procedures" on page 24 of the manual.

3.   Damage may occur to the transducer wires if the transducer assembly is not carefully orientated when fastening to the SR50 housing. The transducer assembly should be positioned in such a way that the wires are sure to remain within the inside wall of the housing. This area is within the dark circle shown on the diagram below. This will keep the wires from getting pinched between the transducer assembly and SR50 housing.

FILTERED
VENT HOLE

BRACKET
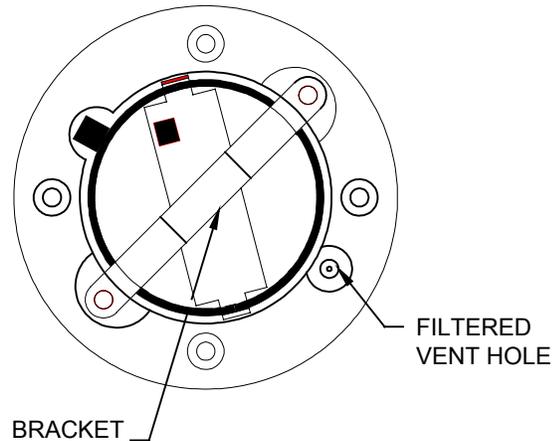
SR50 Sonic Ranging Sensor

1. SR50 Specifications
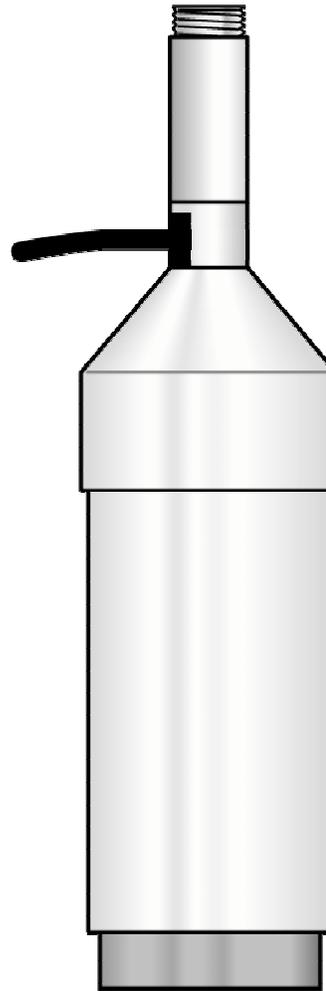
Power Requirements:	9-16 VOLTS D.C.
Power Consumption:	2 mA (Quiescent) 250 mA (Measurement Peak)
Measurement Time:	0.6 seconds typical 3.0 seconds max.

Output:	SDI-12 (version 1.2)
	Serial ASCII
	  - 300 and 1200 Baud TTL or RS-232
	  - 9600 Baud RS-232 only
	Pulse Train (0 to 5 Volts)

Measurement Range:	0.5 to 10 meters
Accuracy:	±1 cm or 0.4% of distance to target (whichever is greater) requires external temperature compensation
Resolution:	0.1mm
Beam Acceptance Angle:	Approximately 22°
Operating Temperature:	-30°C to +50°C Standard (extended temperature available)
Maximum Cable Length:	60 meters (SDI-12 & ASCII) 300 meters (Pulse train)
Cable Type:	Part number L9720, 4 conductor, 2-twisted pair, 22 AWG, Santoprene
Dimensions:	Length 31 cm Diameter 7.5 cm
Weight:	1.3 kg

2. Introduction

The SR50 Sonic Ranging Sensor measures the distance from the sensor to a target. The most common applications are measuring snow depths and water levels. The sensor is based on a 50 kHz (Ultrasonic) electrostatic transducer. The SR50 determines the distance to a target by sending out ultrasonic pulses and listening for the returning echoes that are reflected from the target. The time from transmissions to return of an echo is the basis for obtaining the distance measurement. Since the speed of sound in air varies with temperature, an independent temperature measurement is required to compensate the distance reading. A simple calculation is applied to initial readings for this purpose.

The SR50 is capable of picking up small targets or targets that are highly absorptive to sound--such as low density snow. The SR50 can measure multiple targets and it makes use of a unique echo processing algorithm to help ensure measurement reliability. If desired, the SR50 can also output a data value indicative of measurement quality (not available for pulse train output).

The SR50 was designed to meet the stringent requirements of snow depth measurement which makes it well suited for a variety of other applications. The rugged aluminum housing is built to withstand harsh environments and offers several mounting options.

3. Operation

The SR50 has several output formats: SDI-12, Pulse Train, and serial ASCII output. A group of four jumpers inside the SR50 allow setting an address for SDI-12 operation or as an option setting for Pulse Train and ASCII outputs.

The SR50 performs multiple echo processing regardless of output formats. The SR50 bases every measurement on several readings and applies an algorithm to improve measurement reliability. When using SDI-12 or ASCII output, up to 3 targets can be detected with the SR50 provided the difference between their height is > 0.4 meters.

The distance to target readings that are obtained from the sensor are referenced from the metal mesh on the face of the transducer. The SR50 has a field of view of approximately 22°. The closest object to the sensor will be detected if it is within this field of view. If a target is in motion, the SR50 may reject a reading if the target distance changes at a rate of 4 centimeters per second or more.

Under most circumstances the SR50 will complete a measurement within 1 second and begin outputting the data. If the SR50 rejects a reading or does not detect a target, it will retry. The maximum time limit to remain in measurement state for retries is 3 seconds. If the reading is not obtained during this time limit, the SDI-12 and ASCII options will output zeroes for distance to target and measurement quality numbers (see below for description of quality numbers).   The Pulse Train option will output a single pulse.

Measurement quality numbers are also available with the SDI-12 and the ASCII output formats; these give an indication of the measurement certainty. The quality numbers have no units of measure but can vary from 162 to 600. Numbers lower than 210 are considered to be measurements of good quality. A value of zero however, indicates a reading was not obtained. Numbers greater than 300 indicate that there is a degree of uncertainty in the measurement. Causes of high numbers include:

- the sensor is not perpendicular to the target surface
- the target is small and reflects little sound
- the target surface is rough or uneven
- the target surface is a poor reflector of sound (low density snow)

It is not necessary to make use of the quality numbers but they can provide additional information such as an indication of surface density in snow monitoring applications.

The SR50 does not include a temperature sensor to compensate for variations in air temperature. Campbell Scientific recommends the Model 107 air temperature probe for this purpose. A radiation shield may be required. Temperature compensation must be applied to the sensor output using the following formula:

$$DISTANCE = READING_{SR50}\sqrt{\frac{T°KELVIN}{273.15}}$$

FORMULA 1. Temperature Compensation

The SR50 calculates a distance reading using the speed of sound at 0°C (331.4 m/s). If the temperature compensation formula is not applied, the distance values will not be accurate for temperatures other than 0°C. A temperature compensated distance is obtained by multiplying the SR50 reading by the square root of the air temperature in degrees Kelvin divided by 273.15. An example program that includes this correction is shown in Section 3.2.

SPECIAL CAUTION

But only for SR50's with a detachable cable and connector directly on the sensor housing.

On rare occasions, measurements made by the SR50 can be adversely influenced by strong electromagnetic fields. Electromagnetic fields can be generated by the operation of heavy electrical machinery and the presence of radio frequencies with field strengths greater than 3V/m. Symptoms of this problem are erroneous measurements randomly dispersed among accurate measurements.

This problem can be fixed by tying the probe body to earth ground. This is done by scraping away a small patch of the clear anodize coating and attaching a bare section of stranded wire over the scraped area with a band clamp. Copper wire and a stainless steel band clamp work best. It is recommended to confirm with an ohmmeter that the copper wire is making contact to the probe body.

3.1 SDI-12 Operation

SDI-12 is a Serial Digital Interface standard that is used for communication between data recorders and sensors. Campbell Scientific's CR10(X), CR500, CR510, CR23X, BDR320, and CR200 series dataloggers have the capability to read SDI-12 sensors (CR10's with the correct PROM can do SDI-12).

The SR50 can be set to one of ten addresses (0 to 9) which allows up to ten sensors to be connected to a single digital I/O channel (control port) of an SDI-12 datalogger.

The SR50 is shipped from the factory with the address set to 0. The SR50 needs to be opened in order to change the SDI-12 address. Refer to Section 7.0 for details on opening the SR50 and Figure 8 for the Address/Option jumper settings.

When it is necessary to measure more than one SR50, it is easiest to use a different control port for each SR50 instead of changing the address in each SR50.

3.1.1 SDI-12 Wiring

Color	Function	Datalogger Connection
Black	Ground	Ground (G)
Red	+12V	+12V
Green	SDI-12 Bus	Control Port
White	Ground	Ground (G)
Clear	Shield	Ground (G)
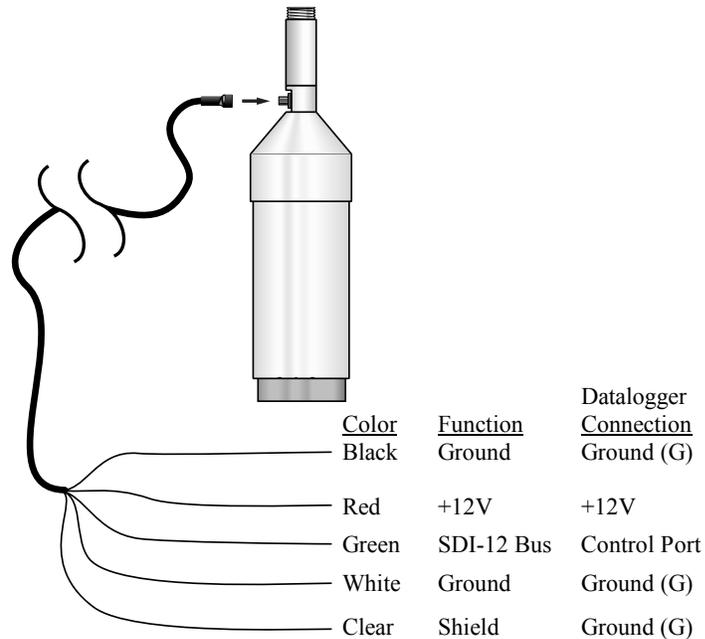
FIGURE 1. SDI-12 Wiring

CAUTION The order in which the connections are made is critical. Always connect Ground first, followed by +12V and then the remaining SDI-12/Data Bus, Sensor Enable Line and Shield. When disconnecting the sensor, the reverse order should be followed.

The SDI-12 protocol has the ability to support various measurement commands. The SR50 supports the commands that are listed in Table 1.

Depending on the application, different measurement commands may be selected. The different commands are entered as options in Parameter 2 of instruction 105. The major difference between the various measurement commands is the data that are returned. The user has the options to output the distance to target in meters or feet, include the measurement quality numbers, and to include multiple target detection.

The "8" command outputs the first detected echo in meters as in the "0" command. However, the "8" command disables retries to ensure a fast measurement. Under poor measurement conditions it may take as long as 3 seconds to obtain a measurement. For users who find this length of time unacceptable selecting the "8" command ensures that the sensor will complete the measurement within a one second period by disabling retries.

If the SR50 is unable to detect a proper echo for a measurement, the sensor will return a zero value for the distance to target value. When the multiple target

output option is selected, the SR50 will return three distance to target values that are arranged in order from closest to the furthest. If no targets were detected, the SR50 outputs three zeroes.

The "10" command requests the sensor to perform a self check. This will verify the CPU operation and generate a ROM signature value to verify the software version that is in the sensor.

SR50's with software version 1.1 have Concurrent Measurement capability. With this ability, the datalogger can initiate measurements with several SDI-12 devices without having to wait for each individual sensor to complete its sequence before proceeding to the next program instruction. This can speed up the datalogger program if that is a concern. For Campbell datalogger users, see the datalogger manual Section 9 105 SDI-12 RECORDER instruction description. At present, the CR10X, CR510, and CR23X with recent OS have this ability.

More detailed instructions and a programming example is located in APPENDIX A.
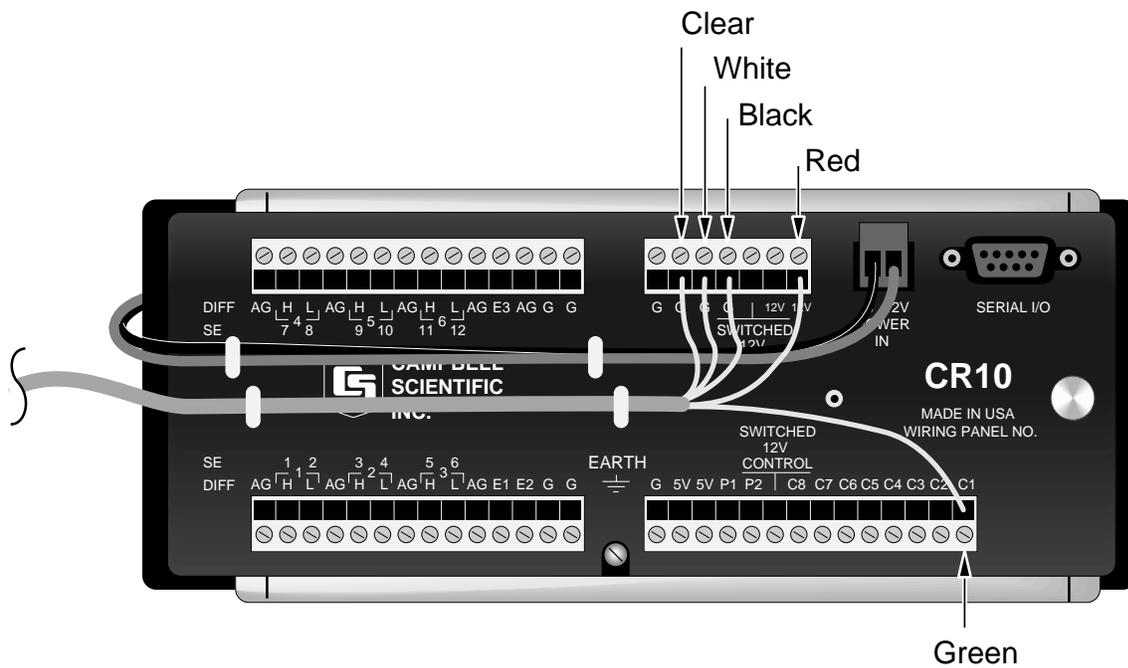
FIGURE 2. SR50 Wiring for CR10(X) SDI-12 Example

3.2 SDI-12 CR10(X) Program Example

In this example, the SR50 is mounted 2 meters above the ground. Snow depth and a quality of measurement number is the desired output. This program uses Instruction 105 (refer to the CR10(X) manual for details on the SDI-12 Recorder Instruction) to obtain a distance measurement from the SR50. The SR50's address is 0. It is assumed that a Campbell Scientific 107 Temperature

Probe is used and that the SR50 SDI-12/DATA Bus is wired to control port 1 (see Figure 2).

This program is similar to that used on a CR23X.

```
;{CR10X}
;
*Table 1 Program
  01:  60            Execution Interval (seconds)


; Measure the 107 temperature probe.
1:  Temp (107) (P11)
  1:  1              Reps
  2:  1              SE Channel               ; S.E. Chan #1 used for this example
  3:  1              Excite all reps w/E1     ; Excite Chan #1 used for this example
  4:  1              Loc [ T_KELVIN  ]
  5:  1              Mult
  6:  273.15         Offset                   ; This converts the value to degrees Kelvin.


; Measure the SR50 using code '1' for parameter 2.  This will cause the SR50 to measure the
distance to target (in meters) and provide a measurement quality number.


2:  SDI-12 Recorder (P105)
  1:  0              SDI-12 Address
  2:  1              Start Measurement (aM3!)  ; <<< code '1' is used (SEE TABLE 1).
  3:  1              Port                      ; Control Port 1 used for this example.
  4:  2              Loc [ DEPTH  ]            ; Two input locations are used. One for distance and
  5:  -1             Mult                      ; one for measurement quality.
  6:  0              Offset


; Instruction 105 initiates the measurement using the "0" command in Parameter 2.  The single value
; returned to Input Location 2 is the distance to the surface in meters.  A multiplier of -1 is used
; because the distance to target value will be subtracted from the distance to ground value to obtain
; snow depth (see 8th instruction).


; The next four instructions apply temperature compensation to the distance value.
3:  Z=F x 10^n (P30)
  1:  273.15         F
  2:  0              n, Exponent of 10
  3:  4              Z Loc [ REF_TEMP  ]

4:  Z=X/Y (P38)
  1:  1              X Loc [ T_KELVIN  ]
  2:  4              Y Loc [ REF_TEMP  ]
  3:  5              Z Loc [ MULT     ]

5:  Z=SQRT(X) (P39)
  1:  5              X Loc [ MULT     ]
  2:  5              Z Loc [ MULT     ]
```

```
6:  Z=X*Y (P36)
  1:   2          X Loc [[ DEPTH    ]
  2:   5          Y Loc [ MULT      ]
  3:   2          Z Loc [[ DEPTH    ]


7:  Z=X+F (P34)
  1:   2          X Loc [ DEPTH    ]
  2:   2.0        F                          ; <<<<<<<<<<< Insert the distance from sensor to bare ground
  3:   2          Z Loc [ DEPTH    ]    ; This is actual snow depth.

; Hourly data output…
8:  If time is (P92)                        ; Output data at the interval you require for your data analysis.
  1:   0          Minutes (Seconds --) into a
  2:   60         Interval (same units as above)
  3:   10         Set Output Flag High (Flag 0)

9:  Set Active Storage Area (P80)
  1:   1          Final Storage Area 1
  2:   60         Array ID                   ; This sets the array ID# to be '60'.

10:  Real Time (P77)                         ; Output a time stamp with the data.
  1:   1220       Year,Day,Hour/Minute (midnight = 2400)

11:  Sample (P70)                            ; Sample the snow depth  and measurement
  1:   2          Reps                       ; quality number.
  2:   2          Loc [ DEPTH  ]

-Input Locations-
1 T_KELVIN
2 DEPTH
3 SIG_QUAL1
4 REF_TEMP
5 MULT
```

TABLE 1. SR50 SDI-12 Command List

CR10X and CR23X P105 Parameter 2 Options	SDI-12 COMMANDS When using non-Campbell Loggers	FUNCTION	DATA OUTPUT
0	aM	First Target (Meters)	D1
1	aM1	First Target (Meters) with Quality Number	D1,Q1
2	aM2	Multiple Targets (Meters)	D1,D2,D3
3	aM3	Multiple Targets (Meters) with Quality Numbers	D1,D2,D3,Q1,Q2,Q3
4	aM4	First Target (Feet)	D1
5	aM5	First Target (Feet) with Quality Number	D1,Q1
6	aM6	Multiple Targets (Feet)	D1,D2,D3
7	aM7	Multiple Targets (Feet) with Quality Numbers	D1,D2,D3,Q1,Q2,Q3
8	aM8	First Target (Meters) No Retries	D1
N/A	aD0	Send Data	DEPENDENT UPON COMMAND SENT
10	aV	Start Verification calculates ROM Signature	NUMERIC SIGNATURE
	aI	Send Identification	012CAMPBELLSR50 1.1 NOTE: There are 2 spaces between SR50 and 1.1
0--	aC	Concurrent Measurement*	D1
n--	aC*n*	Concurrent Measurements*	Same as M – M8

Where a = address of SDI-12 device.
Where *n* = numbers 1 to 8.
* = see APPENDIX A for details about Concurrent Measurements.

3.3 Pulse Train Output

This option is most commonly used with 21X or CR10s without SDI-12. The SR50 sensor can also output a pulse train to represent the distance to target value. The pulse train option outputs a series of 5 Volt pulses on the SDI-12/Data Bus with each pulse representing a distance to target unit. Several options are available in the type of pulse train that is output. The pulse frequency can be selected as either 1000 Hz or 100 Hz. Selectable units are 2.5 mm/pulse, 1cm/pulse, or 0.1 inch/pulse.

Because the 21X datalogger does not have SDI-12 capabilities, the SR50's pulse train output is measured using the datalogger's P3 Pulse Count instruction. Configure the pulse channel as "high frequency" with option 00.

All CR10X, CR510, and CR23X dataloggers have SDI-12 capabilities. Typically the SR50 is measured with the SDI-12 output format with CR10 dataloggers. If your CR10 does not have SDI-12 capabilities, the SR50's pulse train output is measured using the datalogger's P3 Pulse Count instruction. Configure the CR10 pulse channel as "low level ac" with option 01.

To place the sensor in Pulse Train mode, select the desired option by setting the internal Address/Option jumpers (see Figure 8) according to the list in Table 2. Only addresses 0 to 5 are applicable for the Pulse Train output. The sensor initiates the measurement when the Sensor Enable Line is pulsed high to +5 Volts. The pulse width should be a minimum of 5 ms and a maximum of 250 ms in width. When the SR50 detects that the Sensor Enable Line is high, it makes a measurement. When complete, the SR50 outputs the appropriate pulse train on the SDI-12 Bus. The SR50 will output the number of pulses based on the closest target that was detected. If the SR50 is unable to detect any targets, the sensor will output a single pulse to indicate that no reading was obtained.

Please note that it is more critical to consider the time it takes to make a measure and transmit the result with this option. After the SR50 detects the pulse on the Sensor Enable Line, the measurement begins and can take up to 3 seconds before the pulse train begins. The time required to transmit the pulse train varies significantly depending on the pulse option selected and the distance to target. For example, if a target was 5 meters from the sensor and the 1000 Hz, 1 cm/pulse option was selected, the pulse train would require 0.5 seconds to transmit. If the 100 Hz, 2.5mm/pulse option were selected for the same distance, the pulse train would require 20 seconds.

It is also important not to leave the Sensor Enable Line high for too long. If the sensor completes the measurement, and detects that the Sensor Enable Line is still high it will immediately initiate another measurement and output a second pulse train. This may cause a second pulse train to be counted and added with the first pulse train creating an error in the measurement recorded.

3.3.1 Pulse Training Wiring

Color	Function	Datalogger Connection
Black	Ground	Ground (G)
Red	+12V	+12V
Green	Data Bus	Pulse Channel
White	Sensor Enable	Control Port
Clear	Shield	Ground (G)
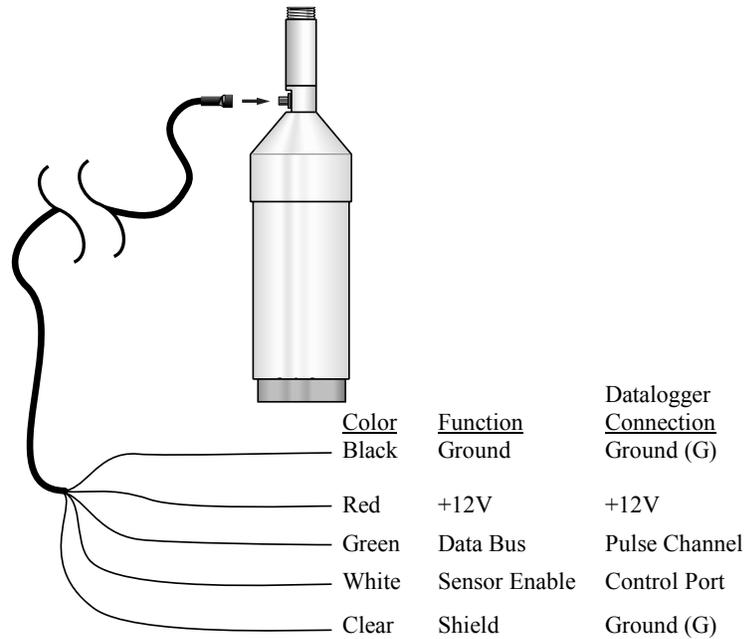
FIGURE 3. Pulse Train Wiring

CAUTION	The order in which the connections are made is critical. Always connect ground first, followed by +12V and then the remaining SDI-12/Data Bus, Sensor Enable Line and Shield. In disconnecting the sensor the reverse order should be followed.

3.4 Two 21X Program Examples for Pulse Train Output
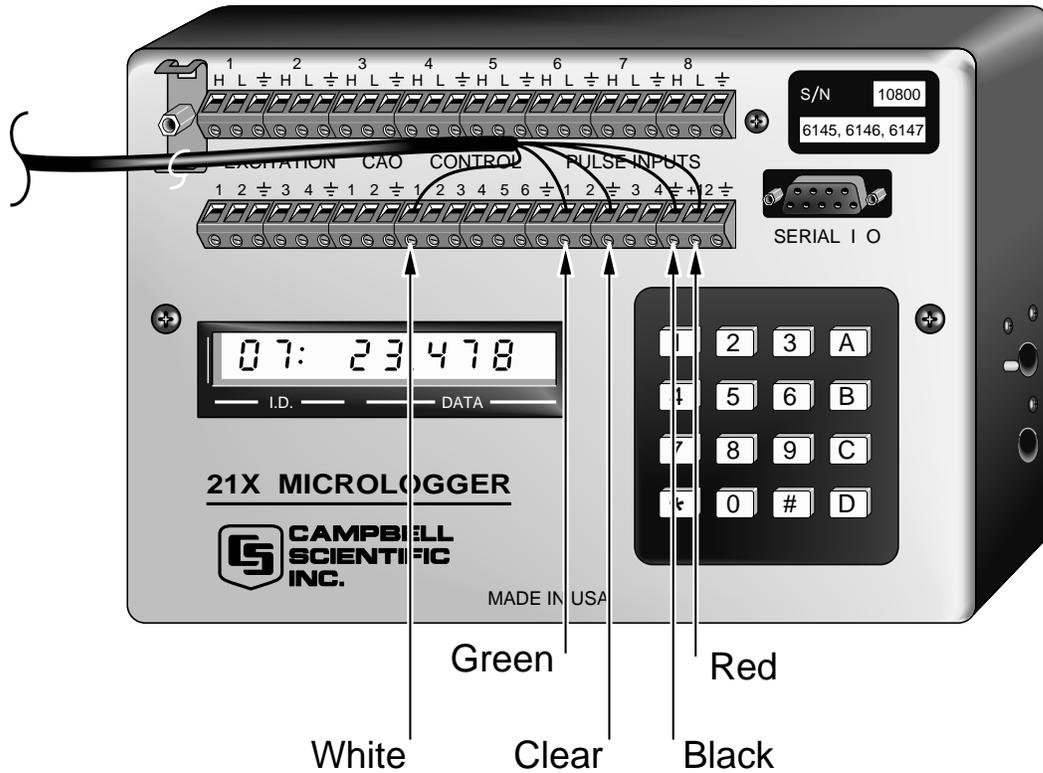
FIGURE 4. SR50 Wiring for 21X Pulse Example

The programming examples assume that the sensor is mounted 2 meters above the ground and the desired output is snow depth in meters. In these examples a 21X micrologger is used to read the SR50 with the pulse train option. The number of pulses are counted on Pulse channel 1.

3.4.1 Pulse Train Programming Example 1

Example 1 will measure every execution interval.

```
* Table 1 Program
  01: 10.0           Execution Interval (seconds)
```

NOTE The Execution Interval must be long enough to count all pulses generated by the SR50.

The number of pulses is dependent on the SR50 jumper setting and distance to target.

The following instructions set the sensor enable line high long enough for the SR50 to detect it, then set it low.

```
1: Set Port (P20)
  1:  1            Set High
  2:  1            Port Number

2: Excitation with Delay (P22)
  1:  1            Ex Chan
  2:  1            Delay w/Ex (units = 0.01 sec)
  3:  0000         Delay After Ex (units = 0.01 sec)
  4:  0.0          mV Excitation

3: Set Port (P20)
  1:  0            Set Low
  2:  1            Port Number
```

The P3 instruction counts the pulse train being transmitted from the SR50. Distance-to-surface will automatically be reset to 0.00 after the distance is calculated and stored for later processing and output.

```
4: Pulse (P3)
  1:  1            Reps
  2:  1            Pulse Input Chan
  3:  00           Config Option
  4:  21           Loc [ Dis2Surf ]
  5:  -.0025       Mult
  6:  0.0          Offset
```

Measure air temperature and convert to degrees Kelvin. This example assumes air temperature is being measured with Campbell Scientific's Model 107 probe.

```
5: Temp 107 Probe (P11)
  1:  1            Reps
  2:  1            In Chan
  3:  1            Excite all reps w/Exchan 1
  4:  22           Loc [ T_Kelvin ]
  5:  1            Mult
  6:  273.15       Offset
```

Compute the air temperature compensation factor and correct the distance-to-surface for air temperature (see formula 1).

```
6: Z=F (P30)
  1:  273.15       F
  2:  23           Z Loc [ 273_15   ]

7: Z=X/Y (P38)
  1:  22           X Loc [ T_Kelvin ]
  2:  23           Y Loc [ 273_15   ]
  3:  24           Z Loc [ ATempComp ]
```

```
8:  Z=SQRT(X) (P39)
  1:   24          X Loc [ ATempComp ]
  2:   24          Z Loc [ ATempComp ]


9:  Z=X*Y (P36)
  1:   21          X Loc [ Dis2Surf  ]
  2:   24          Y Loc [ ATempComp ]
  3:   21          Z Loc [ Dis2Surf  ]
```

Add distance-to-ground to distance-to-snow (which is negative) to calculate snow depth.

In the following instruction, Parameter 2 is a constant. You enter the distance-to-ground at your site.

```
10:  Z=X+F (P34)
  1:   21          X Loc [ Dis2Surf  ]
  2:   2.00        F
  3:   10          Z Loc [ SnowDepth ]
```

An hourly output example, yours may vary.

```
11:  If time is (P92)
  1:   0           Minutes into a
  2:   60          Minute Interval
  3:   10          Set Output Flag High

12:  Real Time (P77)
  1:   0220        Day,Hour/Minute (prev day at midnight, 2400 at midnight)

13:  Sample (P70)
  1:   1           Reps
  2:   10          Loc [ SnowDepth ]

*  Table 2 Program
  02: 0.0          Execution Interval (seconds)

*  Table 3 Subroutines

End Program

-Input Locations-
  10   SnowDepth
  21   Dis2Surf
  22   T_Kelvin
  23   273_15
  24   ATempComp
```

3.4.2 Pulse Train Programming Example 2

Example 2 will measure every execution interval.

This program will measure the SR50 when Flag 1 is set high, which can be done manually and/or at a specified interval. All instructions above those that define the Output Interval must remain together. Note that in this example the datalogger program executes every 10 seconds, but the SR50 measures and processes only every 15 minutes. This results in considerable power savings at remote sites without giving up data. This also allows the user to trigger a scan at any time.

```
*  Table 1 Program
   01:  10.0           Execution Interval (seconds)
```

NOTE   The execution interval must be long enough to count all pulses generated by the SR50. The number of pulses is dependent on the SR50 address setting and distance to target.

As configured from the factory (Address 0), it will take 4 seconds to measure 10 meters. Shorter distances will take less time.

Measure air temperature and convert to Kelvin. This measurement must represent the temperature of air where the SR50 is operating.

```
1:  Temp 107 Probe (P11)
   1:   1             Reps
   2:   1             In Chan
   3:   1             Excite all reps w/Exchan 1
   4:   22            Loc [ T_Kelvin  ]
   5:   1             Mult
   6:   273.15        Offset
```

Enable the Pulse Count instruction (P3) to count pulses from the SR50 when they are generated. The negative multiplier will generate a negative distance-to-surface so that when the distance-to-ground is added distance-to-surface, snow depth is computed.

The Distance-to-surface will be set to 0.00 after measurement.

```
2:  Pulse (P3)
   1:   1             Reps
   2:   1             Pulse Input Chan
   3:   00            Config Option
   4:   21            Loc [ Dis2Surf  ]
   5:   -.0025        Mult
   6:   0.0           Offset
```

If Flag 2 is high, compute the air temperature compensation factor and correct the distance-to-surface measurement for air temperature (see Formula 1).

```
3:  If Flag/Port (P91)
  1:   12          Do if Flag 2 is High
  2:   30          Then Do

4:  Z=F (P30)
  1:   273.15      F
  2:   23          Z Loc [ 273_15   ]

5:  Z=X/Y (P38)
  1:   22          X Loc [ T_Kelvin  ]
  2:   23          Y Loc [ 273_15    ]
  3:   24          Z Loc [ ATempComp ]

6:  Z=SQRT(X) (P39)
  1:   24          X Loc [ ATempComp ]
  2:   24          Z Loc [ ATempComp ]

7:  Z=X*Y (P36)
  1:   21          X Loc [ Dis2Surf  ]
  2:   24          Y Loc [ ATempComp ]
  3:   21          Z Loc [ Dis2Surf  ]
```

Add distance-to-ground to distance-to-snow (which is negative) to calculate snow depth.

In the following instruction, Parameter 2 is a constant. You enter the distance-to-ground at your site.

```
8:  Z=X+F (P34)
  1:   21          X Loc [ Dis2Surf  ]
  2:   2.0         F
  3:   25          Z Loc [ Temporary ]
```

Move snow Depth to another location so that it can be viewed.

```
9:  Z=X (P31)
  1:   25          X Loc [ Temporary ]
  2:   10          Z Loc [ SnowDepth ]

10: Do (P86)
  1:   22          Set Flag 2 Low

11: End (P95)
```

Measure the sensor every 15 minutes by setting Flag 1 high.

Parameter 2 of P92 determines how often to measure.

```
12: If time is (P92)
  1:   0            Minutes into a
  2:   15           Minute Interval
  3:   11           Set Flag 1 High

13: If Flag/Port (P91)
  1:   11           Do if Flag 1 is High
  2:   30           Then Do
```

Enable the sensor by pulsing Control Port 1.

```
14: Set Port (P20)
  1:   1            Set High
  2:   1            Port Number

15: Excitation with Delay (P22)
  1:   1            Ex Chan
  2:   1            Delay w/Ex (units = 0.01 sec)
  3:   0000         Delay After Ex (units = 0.01 sec)
  4:   0.0          mV Excitation

16: Set Port (P20)
  1:   0            Set Low
  2:   1            Port Number

17: Do (P86)
  1:   21           Set Flag 1 Low

18: Do (P86)
  1:   12           Set Flag 2 High

19: End (P95)
```

This is an example or an Hourly output array, yours may vary.

```
20: If time is (P92)
  1:   0            Minutes into a
  2:   60           Minute Interval
  3:   10           Set Output Flag High

21: Real Time (P77)
  1:   0220         Day,Hour/Minute (prev day at midnight, 2400 at midnight)

22: Sample (P70)
  1:   1            Reps
  2:   10           Loc [ SnowDepth ]*

End Program
```

```
-Input Locations-
   10   SnowDepth
   21   Dis2Surf
   22   T_Kelvin
   23   273_15
   24   ATempComp
   25   Temporary
```

3.5 ASCII Output

The SR50 sensor is also capable of outputting data in printable ASCII format. With the ASCII output option, serial ASCII data (0 and 5 volt levels only) is output on the SDI-12/Data Bus. Several options define the type of ASCII data output. The baud rates of 300 and 1200 can be selected as either TTL or RS-232 logic levels. The baud rate of 9600 can only be selected as RS-232. With either selection you can output the first target only or all three targets with quality numbers (See Table 2).

To use the sensor in this mode of operation select the desired option by setting the internal address jumpers according to the list in Table 2 (only addresses 6 to 14 apply for the ASCII output mode). To initiate the measurement, pulse the Sensor Enable Line high to +5 Volts. The pulse width should be a minimum of 5 ms and a maximum of 250 ms. Once the SR50 detects the Sensor Enable Line has gone high, it makes a measurement. When the measurement is finished, the SR50 outputs the appropriate serial data. If the SR50 is unable to detect any targets, the sensor will output zeroes to indicate that no reading was obtained. In this case, measurement quality numbers will also be zero.

The ASCII data format is 8 data bits, no parity, 1 start bit, and 1 stop bit. The distance values are a maximum of 5 digits with a decimal point and a polarity sign. When multiple echoes are requested with quality numbers, the 3 distance numbers precede the quality numbers. The quality numbers are 3 digit values with a decimal point and a polarity sign. All character strings that are returned in the ASCII output mode end with a carriage return and a line feed.

The following are two examples of data that are returned from the SR50. The first example is one echo only. The second example is multiple echoes with quality numbers.

   +1.85<CR><LF>

   +1.85 +3.71 +5.28   +172 +188 +196<CR><LF>
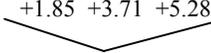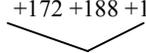
              Echos   Quality #s

TABLE 2. Address Jumper Settings for Pulse Train and ASCII Outputs	
ADDRESS	**OUTPUT FORMAT**
0	Pulse Train 1000 Hz 2.5mm/Pulse
1	Pulse Train 100 Hz 2.5mm/Pulse
2	Pulse Train 1000 Hz 1cm/Pulse
3	Pulse Train 100 Hz 1cm/Pulse
4	Pulse Train 1000 Hz 0.1 inch/Pulse
5	Pulse Train 100 Hz 0.1 inch/Pulse
6	RS-232 1200 BAUD (3 Targets (Meters) with Quality Numbers)
7	RS-232 300 BAUD (3 Targets (Meters) with Quality Numbers)
8	TTL 1200 BAUD (3 Targets (Meters) with Quality Numbers)
9	TTL 300 BAUD (3 Targets (Meters) with Quality Numbers)
10	RS-232 1200 BAUD (First Target (Meters))
11	RS-232 300 BAUD (First Target (Meters))
12	TTL 1200 BAUD (First Target (Meters))
13	TTL 300 BAUD (First Target (Meters))
14	RS-232 9600 BAUD (Single Target (Meters))
15	Factory Test Mode

4. Sensor Mounting and Installation

When mounting the SR50, the sensor's beam angle needs to be considered (see Figure 5). It is important to remember that the SR50 has a beam angle of approximately 22 degrees. This means that no objects should obstruct the intended target within this 22 degree beam. If an obstruction is within this beam angle the SR50 may detect the unwanted object instead of the intended target. By inserting a height value in Formula 2, a Clearance Radius in the same measurement units as the height can be obtained.

$$CONE_{radius} = 0.194\left(CONE_{height}\right)$$

FORMULA 2. Clearance Radius
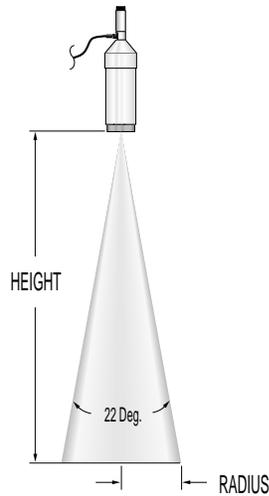
FIGURE 5. SR50 Cone Angle

The SR50's mounting stem (1.25" outside diameter) enables various installation options. A 3/4" x 1" pipe crossover (model L1049, 1.25" x 1" inside diameter) enables the SR50 to mount to any 3/4" pipe (1" outside diameter). The SR50's mounting stem also has 1" pipe thread to accommodate other threaded installation options. Campbell Scientific offers hardware that enables mounting the SR50 to towers (see Figures 6a and 6b) or a vertical pipe with 0.75" to 1.25" diameter.
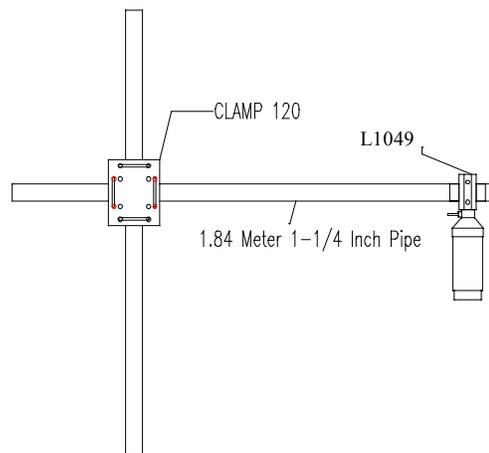
FIGURE 6a. SR50 Tripod Mount
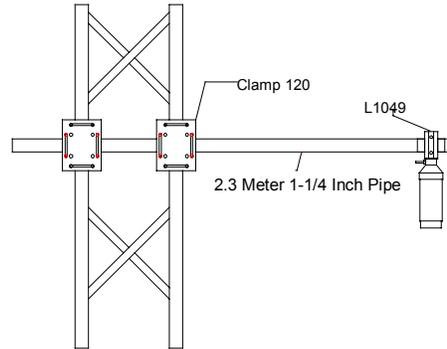
FIGURE 6b. SR50 Tower Mount

The SR50 should be mounted perpendicular to the target surface. If the sensor is mounted at an angle, it will reduce the sensor's ability to detect the target surface. Figure 7 demonstrates the difference between an SR50 that is mounted properly and one that is not. Perpendicular mounting and maintaining an unobstructed path are both demonstrated.

For accuracy it is also important that the SR50 mounting be sturdy and resistant to movement. If the SR50 or the target experiences excessive movement during a measurement, the SR50 may reject the readings. Large fluctuations in the distance readings at rates of 4 cm/sec or more may cause the SR50 to reject a reading and output a zero as the distance to target. If vibration is the concern, it could be reduced by using guy wires on the mounting structure.

To improve the accuracy of the sensor readings it is beneficial to mount the sensor as close to the target as possible. Some errors that are associated with the measurement are a percentage of the distance to target. As a result, the closer the SR50 is to the target the lower the absolute errors will be. However, the SR50 should not be mounted closer than 0.5 meters to a target.

Errors in the temperature measurement translate to errors in the distance reading. For proper temperature compensation a temperature measurement should be made that is representative of the sound path to the target.

Once the sensor has been installed, the output will be the distance from the sensor (referenced from the transducer screen) to the surface. An independent measurement should be made to confirm the accuracy of the results.

Unobstructed Path

Perpendicular to Surface
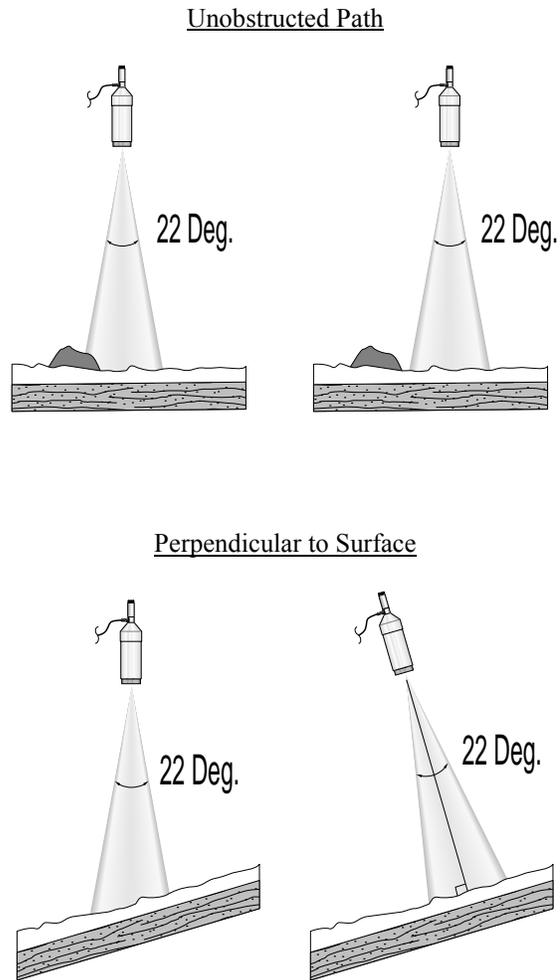
FIGURE 7. SR50 Mounting Considerations

5. Data Interpretation

The SR50 makes use of an effective algorithm to help prevent false readings and to improve the sensor accuracy. Retries and sensitivity adjustments are also part of the echo detection algorithm. It is important to remember that under certain circumstances the SR50 may not be able to obtain a reading.

One such example is snow of extremely low density. In this situation, the surface may not reflect enough sound for the sensor to detect. The SR50 will output zero for the distance to target or a single pulse in the pulse output mode. Zero measurements will likely cause problems in processed data output (e.g., averages, minimum) of averaging scheme or maximum and minimum outputs. For this reason one may choose to check whether or not the value being returned is zero prior to processing and if so, exclude the value with the use of user Flag 9 (Intermediate processing disable).

If multiple targets are requested, the distance values will be reported from closest target to furthest. When using multiple target detection, it is also possible for a sound wave to travel out to the target and back twice which results in the second or third distance to target being approximately twice that of the first target distance (multiples).

Target quality numbers can also be recorded when using the SDI-12 or ASCII output option. The quality numbers provide the user with an indication of the measurement certainty. The quality numbers can vary from 162 to 600. A quality number between 162 and 210 indicates that the SR50 detected a solid target. A number between 210 and 300 is an indication that the target is not definitive and a number between 300 and 600 is an indication that the target is of poor quality (see section 3.0 for possible causes). Though quality numbers of 210 to 600 indicate that the target was not clearly definitive, it does not mean that the measurement was inaccurate. It is only an indication that the SR50 detected a target of poor quality. Consideration should be given when interpreting data with high quality numbers.

5.1 Measuring Snow Depth

The SR50 measures the distance to the surface that it is pointed at. The sensor is mounted above and perpendicular to the surface. To obtain snow depth, the distance to snow must be subtracted from the distance to ground. The instruction that measures the SR50 has a negative multiplier, yielding a negative distance to surface measurement. The negative distance to surface is then corrected for the speed of sound at the measured air temperature. The corrected negative distance to surface is then added to the actual distance to ground that the sensor is mounted at yielding snow depth.

To convert meters to inches, use Instruction 37 to multiply the meters value by 39.370 inches/meter.

```
P37            Z = X x F
01:X           Source location of depth in meters
02:39.370      Fixed multiplier
03:Z           Destination location depth in inches
```

6. Maintenance

The SR50's electrostatic transducer requires equal pressure on both sides. A vent hole in the transducer housing is used to equalize pressure. Desiccant is placed inside the transducer housing to prevent the possibility of condensing humidity. The desiccant must be inspected and, if required, replaced on a regular basis. If the SR50 is used in humid environments, the desiccant should be replaced more frequently. In general, annual replacement of the desiccant in both the transducer housing and the main body is sufficient. To inspect or replace the desiccant, follow the procedures outlined in Section 7 under disassembly.

7. Assembly/Disassembly Procedures

It is important to follow these instructions to disassemble the SR50. Disassembly is required to change the Address/Option jumpers and to inspect or replace the desiccant. There are two small packages of desiccant inside the transducer housing as well as desiccant inside the electronics enclosure (Refer to Figure 8).

IMPORTANT NOTES

Before proceeding with any maintenance on a data acquisition system, always retrieve the data first. It is also recommended that the datalogger program be saved. If possible, do not open the SR50 in a field environment.

Do not remove the two Phillips screws which are countersunk the least. The screws hold the transducer in place. If these screws are removed, do not over tighten them when reassembling. Over tightening will cause the transducer to bend. Apply enough torque only to prevent the washer on the backside from moving. Ensure that the washer is centered properly over the backside of the transducer prior to tightening. Inspect the gold foil of the transducer when complete to ensure that it is not wrinkled from stress due to over tightening the screws.

1. If the sensor is in operation, always disconnect the SR50 from the datalogger before disassembling.

2. To remove the transducer housing, undo the four Phillips screws which are located at the bottom end of the sensor (These are the screws which are countersunk most into the housing identified by the arrows below).
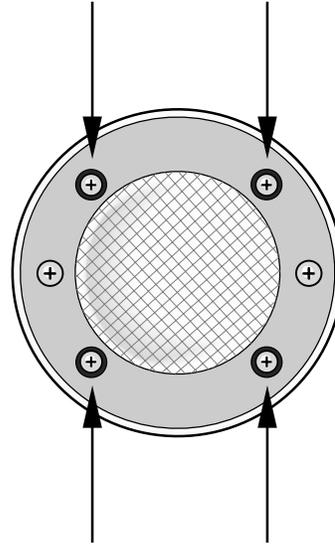

3. The transducer and mount should now fall out. This will expose the desiccant that is in the transducer housing. These small packs of desiccant contain indicating silica gel which turns from blue to pink when they are unable to absorb any more moisture. Look through the small plastic window on the desiccant packs to inspect them.

4. With a Phillips screwdriver remove the two screws that hold the aluminum end plate in place.

5. Pull the end disk out and disconnect the attached wires at the connector. At this point you may inspect or replace the desiccant inside of the cylinder. If the Address/Option jumpers do not need to be changed, then reassemble the SR50 in the reverse order.

6. To obtain access to the address/option jumpers, unscrew the cylinder of the SR50 from the lid and slide the cylinder off. The internal jumpers are now exposed to set the address or to change the sensor's output options.

7. When reassembling the sensor ensure that all the O-rings are properly set in place to ensure a proper seal.

ADDRESS/OPTION JUMPERS
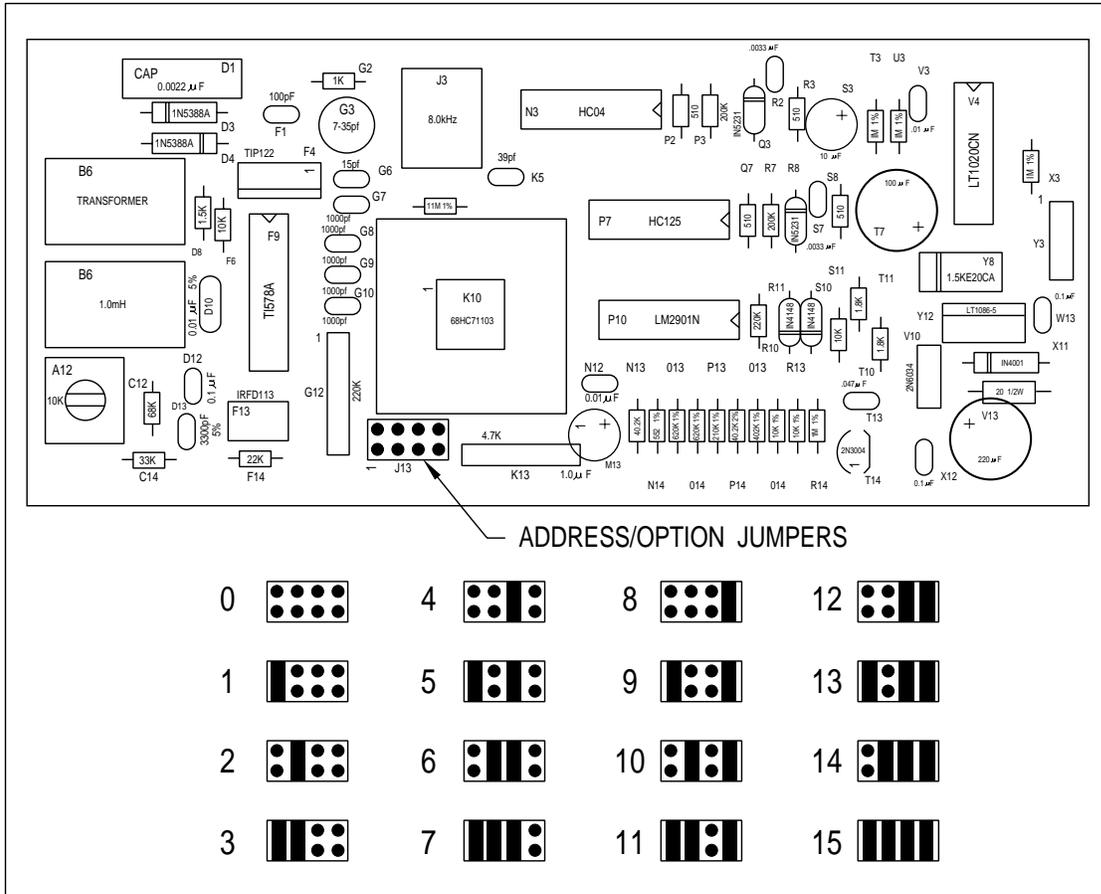
Address 15 for factory use only

FIGURE 8: SR50 Stuffing Chart/Jumper Settings

Appendix A. Making Concurrent Measurements with the SR50

Concurrent Measurement ability allows the datalogging system to initiate measurements in SDI-12 devices and continue processing its program without waiting for a reading from the SDI-12 device. When the sensor has a valid measurement it will send this to the datalogger the next time it is polled. This allows for faster execution of the datalogger program. Concurrent measurement ability is available with SR50's with OS version 1.1 or higher.

The OS Prom in SR50's can be upgraded. Please call a Campbell Scientific representative for details.

Of the Campbell Scientific product line, only the CR510, CR10X, and CR23X dataloggers have the ability to make concurrent measurements. These dataloggers use Program Instruction P105 SDI-RECORDER to measure the SR50. Parameter two of P105 is where the Concurrent Measurement option is set (use option code " # -- " where # is a number 0-8; see Table 1).

To Determine SR50 OS Version:

To determine the version of software in the SR50, insert '10' in parameter 2 of the P105 SDI-RECORDER instruction (SDI-12 command "aI" where a = address). See Table 1 for list of all SDI-12 Commands. The sensor will respond with a numeric signature. If the signature is **63845**, you have version 1.1.

CAUTION:	When using Concurrent Measurement option with several SR50's, it is possible that the sonic pulse from one sensor may interfere or be intercepted by another sensor. For this reason, make sure the sensors are mounted > 30 feet apart. If this is not feasible, it may be necessary to measure them the standard way without Concurrent Measurement or at different times.

Concurrent Measurement Operation:

When Campbell Scientific dataloggers are using concurrent measurement ability with the SR50, they will output –99999 until a reading is received from the sensor. This occurs when using concurrent measurement ability because the sensor receives the command to initialize a reading but does not have a reading to send to the datalogger until the next scan. If the logger does not receive a reading, it shows –99999 in the storage Input location (Numeric Mode *6). The –99999 readings need to be filtered out except when something is wrong, in which case the –99999 will indicate a problem.

The following algorithm is an example of how to filter out –99999 readings. When 3 consecutive readings are bad (-99999) then we want to keep that reading:

Place measurement in Loc X.
If measurement is > -1000 then use measurement
Else
Add 1 to a counter

If the counter = 3 (means there were 3 bad readings in a row) then do:
Use bad reading for measurement.
Reset counter.

Example Program:

In this example, an SR50 is mounted 2 meters above the ground. Snow depth
and measurement quality numbers are the desired output. This program uses
Instruction 105 (refer to Section 9 in the CR10X manual for details on P105
SDI-Recorder Instruction) to obtain a distance measurement from the SR50.
The SR50's address is 0. It is assumed that a Campbell Scientific 107
Temperature Probe is being used and that the SR50 SDI-12/DATA Bus line
(green wire) is wired to control port 1(see Figure 2, page 6 for wiring diagram).

```
;{CR10X}
;

*Table 1 Program
  01: 5             Execution Interval (seconds)

1: Temp (107) (P11)                              ; Measure air temperature
  1:  1            Reps
  2:  1            SE Channel
  3:  1            Excite all reps w/E1
  4:  1            Loc [ AIR_TEMP  ]
  5:  1            Mult
  6:  0            Offset

2: Z=X+F (P34)                                   ; Convert Celsius reading to Kelvin
  1:  1            X Loc [ AIR_TEMP  ]
  2:  273.15       F
  3:  2            Z Loc [ T_KELVIN  ]

; Measure the SR50 using Concurrent Measurement ability...
3: SDI-12 Recorder (P105)
  1:  0            SDI-12 Address
  2:  1   --       Start Measurement (aM1!)      ; <<<<    Configured to provide distance with
  3:  1            Port                          ; echo quality numbers and do concurrent measurement
  4:  3            Loc [ Raw_Dist  ]
  5:  -1.0         Mult
  6:  0.0          Offset
; Check to see if a valid measurement has been returned, and if it has, move
; the measurement to another Input Location to be used as data and reset the
; failure counter.
```

```
4: If (X<=>F) (P89)
  1:   3            X Loc [ Raw_Dist  ]
  2:   3            >=
  3:  -1000         F
  4:   30           Then Do

    5: Z=X (P31)
      1:   3            X Loc [ Raw_Dist  ]
      2:   8            Z Loc [ DEPTH    ]

    6: Z=X (P31)
      1:   4            X Loc [ Raw_Qual  ]
      2:   9            Z Loc [ QUALITY   ]

    7: Z=F x 10^n (P30)
      1:   0.0          F
      2:   00           n, Exponent of 10
      3:   5            Z Loc [ FAILCOUNT ]

8: Else (P94)
```

; If the measurement was not valid, increment the failure counter.
```
    9: Z=Z+1 (P32)
      1:   5            Z Loc [ FAILCOUNT ]
```

; If the failure counter is equal to or larger than a pre-determined number (in this case ; 3),
; allow the -99999 to appear in the data to indicate that there is a problem with the
; measurement. The pre-determined number will depend on the scan rate, and
; should
; indicate the maximum expected -99999 readings prior to a valid measurement being
; returned. The number should be 3 for scan rate greater than three seconds, and
; larger for faster execution rates.

```
    10: If (X<=>F) (P89)
      1:   5            X Loc [ FAILCOUNT ]
      2:   3            >=
      3:   3            F
      4:   30           Then Do

        11: Z=X (P31)
          1:   3            X Loc [ Raw_Dist  ]
          2:   8            Z Loc [ DEPTH    ]

        12: Z=X (P31)
          1:   4            X Loc [ Raw_Qual  ]
          2:   9            Z Loc [ QUALITY   ]

        13: Z=F x 10^n (P30)
          1:   0.0          F
          2:   00           n, Exponent of 10
          3:   5            Z Loc [ FAILCOUNT ]

    14: End (P95)

15: End (P95)
```

```
; Apply air temperature correction to the reading...
16: Z=F (P30)
  1:  273.15      F
  2:  0           Exponent of 10
  3:  6           Z Loc [ REF_TEMP ]

17: Z=X/Y (P38)
  1:  2           X Loc [ T_KELVIN ]
  2:  6           Y Loc [ REF_TEMP ]
  3:  7           Z Loc [ MULT    ]

18: Z=SQRT(X) (P39)
  1:  7           X Loc [ MULT    ]
  2:  7           Z Loc [ MULT    ]

19: Z=X*Y (P36)
  1:  8           X Loc [ DEPTH   ]
  2:  7           Y Loc [ MULT    ]
  3:  8           Z Loc [ DEPTH   ]

20: Z=X+F (P34)
  1:  8           X Loc [ DEPTH   ]
  2:  2.0         F                ; <<<<<<<<<<<< Insert the distance from sensor to bare ground
  3:  8           Z Loc [ DEPTH   ]   ; <<<<  This is actual snow depth.

; Hourly data output...
21: 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)

22: Set Active Storage Area (P80)
  1:  1           Final Storage Area 1
  2:  60          Array ID

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

24: Average (P71)
  1:  2           Reps
  2:  8           Loc [ DEPTH    ]

-Input Locations -
1 AIR_TEMP
2 T_KELVIN
3 Raw_Dist
4 Raw_Qual
5 FAILCOUNT
6 REF_TEMP
7 MULT
8 DEPTH
9 QUALITY
```