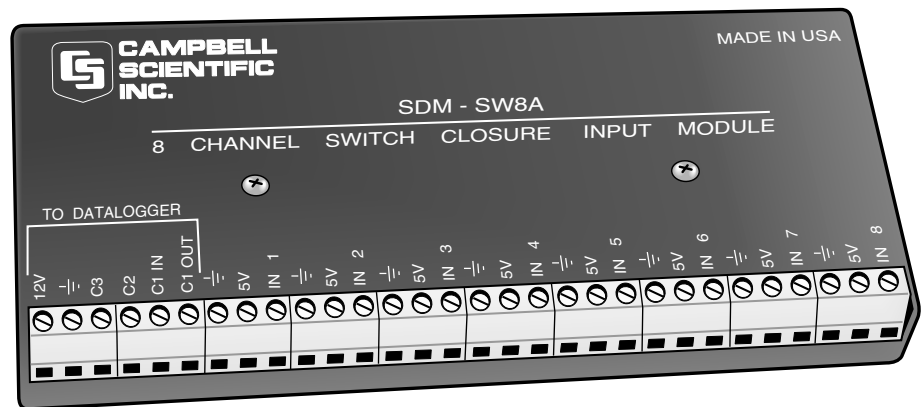


# INSTRUCTION MANUAL



## SDM-SW8A 8 Channel Switch Closure Module

Revision: 7/10



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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<sup>2</sup> (square inch) = 645 mm<sup>2</sup>

**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/in<sup>2</sup>) = 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.

# SDM-SW8A Table of Contents

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*PDF viewers note: These page numbers refer to the printed version of this document. Use the Adobe Acrobat® bookmarks tab for links to specific sections.*

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# SDM-SW8A Switch Closure Input Module

## 1. Function

The 8 channel SDM-SW8A Switch Closure Input Module (see Figure 1) measures up to 8 channels of switch closure or voltage pulse inputs. Each channel may be configured to read single-pole double-throw (SPDT) switch closure, single-pole single-throw (SPST) switch closure, or voltage pulse. Output options include counts, duty cycle, and state.

The SW8A is addressed by the datalogger, allowing multiple SW8As to be connected to one datalogger (refer to Theory of Operation, Section 9). Sixteen addresses are available, but for most applications, Campbell Scientific, Inc. recommends no more than 4 SW8As be connected to one datalogger. If more SW8As are required, please consult Campbell Scientific's Marketing Department.

In October, 1988, the SDM-SW8A was introduced. Edlog Instruction 102 is used for communication with the SW8A. CRBasic dataloggers use the SDMSW8A instruction. Previous to October, 1988, the SDM-SW8 (no "A") was offered for use only with the CR10, utilizing CR10 I/O Instruction 15. **SDM-SW8As are not compatible with CR10s containing Instruction 15, and SDM-SW8s are not compatible with CR10s containing Instruction 102.** Contact Campbell Scientific's Marketing Department for update options if incompatibilities exist.

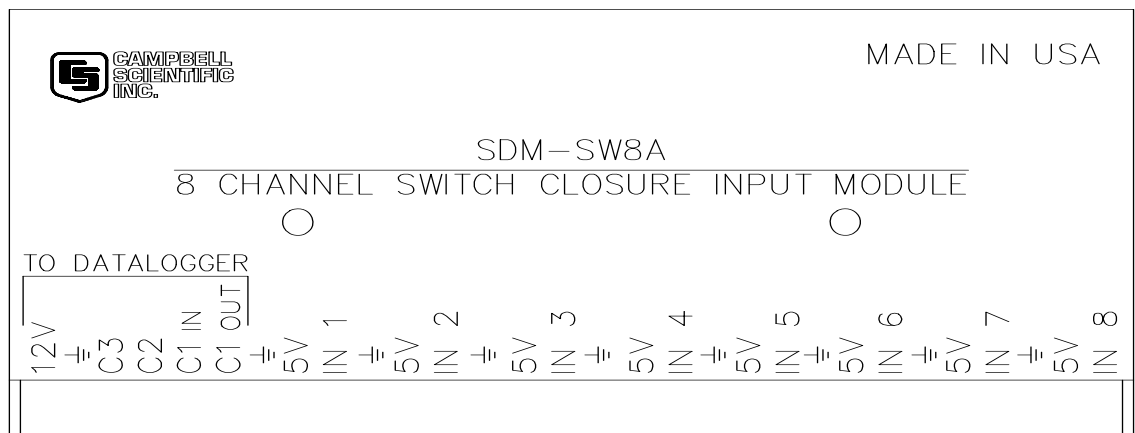


FIGURE 1. SDM-SW8A Front Panel

## 2. Specifications

Operating voltage:	12 VDC nominal (9.6 to 16)
Current drain:	3 mA quiescent, 6 mA active (max)
Environmental:	-25 to +50°C, 0 to 90% RH, noncondensing
Measurement types:	Switch closure (SPDT, SPST) DC voltage pulse
Input voltage threshold:	From below 0.9 to above 4.0 VDC,±20 VDC max
Maximum input frequency:	100 Hz (50% duty cycle)
Minimum input pulse width:	5 ms high, 5 ms low
Maximum bounce time:	3 ms open without counting
Output options:	State, duty cycle, counts
Max count/port:	65535
Internal sampling frequency:	500 Hz
Watchdog reset:	Yes
Total length of connecting cables:	20 feet
Dimensions:	0.9"(H), 6.2"(L), 2.7"(W)
Weight	0.5 lbs. (0.23 kg)
Compatible dataloggers:	CR10(X), CR800, CR850, CR1000, 21X, CR23X, CR3000, CR5000, and CR7

**TABLE 1. Datalogger to SDM-SW8A Connections**

Datalogger				
SDM-SW8A	CR7	CR1000, CR800, CR850, CR23X, CR10(X)	CR3000, CR5000	21X
+12 (see Note 1)	+12	12 V	12 V	+12
⊥	⊥	G	G	⊥
C3	C3	C3	SDM-C3	C3
C2	C2	C2	SDM-C2	C2
C1 IN	C1	C1	SDM-C1	C1
C1 OUT	not used (see Note 2)	not used (see Note 2)	not used (see Note 2)	1H (see Note 2)

**TABLE 2. SDM-SW8A to SDM-SW8A Connections**

<b>SDM-SW8A</b>	<b>SDM-SW8A that's connected to a CR10(X), CR800, CR850, CR1000, CR23X, CR3000, CR5000, or CR7</b>	<b>SDM-SW8A that's connected to a 21X</b>
+12	12 V	+12
$\underline{\underline{\text{G}}}$	$\underline{\underline{\text{G}}}$	$\underline{\underline{\text{G}}}$
C3	C3	C3
C2	C2	C2
C1 IN	C1 IN	C1 IN
C1 OUT	not used (see Note 2)	C1 OUT (see Note 3)

**Notes:**

(1) If using an auxiliary power supply, instead of connecting the datalogger's 12 V or +12 terminal to the SW8A, connect the power supply's positive "+" wire to the SW8A's +12 terminal. The power supply's ground "-" wire connects to the SW8A's  $\underline{\underline{\text{G}}}$  terminal along with the wire that connects to the datalogger's G or  $\underline{\underline{\text{G}}}$  terminal.

(2) When using a CR10(X), CR800, CR850, CR1000, CR23X, CR3000, or CR7, a jumper wire is used to connect the C1 IN to the C1 OUT. SDM-SW8As shipped after March 1, 2006, include this jumper.

(3) If you're using a 21X and the SDM-SW8A was shipped after March 1, 2006, remove the jumper connecting C1 IN to C1 OUT.

### 3. Power Supply Considerations

Due to the 3 mA continuous and 6 mA active current drain, an auxiliary 12 VDC power supply is recommended for powering the SW8A in remote, long term applications.

For some applications it may be convenient to use the datalogger supply to power the SW8A. For long term applications where AC power is available, or where a solar panel can be used for recharging, the lead acid power supply available with Campbell Scientific, Inc. dataloggers could be used. For short term applications only, the alkaline power supply available with Campbell Scientific, Inc. dataloggers could be used to power the SW8A.

If the 21X power supply is used to power the SW8A, all low level analog measurements (thermocouples, pyranometers, thermopiles, etc.) must be made differentially. This results from slight ground potentials created along the 21X analog terminal strip when the 12 V supply is used to power peripherals. This limitation reduces the number of available analog input channels and may mandate an external supply for the SW8A.

## 4. Connections

All connections to the datalogger, power supply, and other SW8As are made from terminals located under "TO DATALOGGER" on the SW8A (refer to Figure 1). Sensor connections are made at the remaining terminals.

### 4.1 Connections to Dataloggers and Other SW8As

The CABLE5CBL or a similar cable is used to connect the SDM-SW8A to a datalogger.

Connections between an SW8A and a datalogger are shown in Table 1. Connections to multiple SW8As are shown in Table 2.

---

**CAUTION**

1. The order in which connections are made is critical. ALWAYS CONNECT GROUND FIRST, followed by 12 V and then the Control Ports.

2. The sum of all the cable lengths connecting SW8As or other SDM devices and a datalogger should be as short as possible and preferably does not exceed 20 ft. Longer lead lengths may be possible for CRBasic dataloggers if the SDMSpeed instruction is used (see Section 6.1.2). Long lead lengths may prevent communication.

---

### 4.2 Sensor Connections

Figure 2 shows the connections between the SW8A and compatible sensor types.

## 5. Internal Jumpers

Inside the SW8A, jumpers must be set to configure the Module address and the channel measurement type for each channel. Remove the two panel screws and lift the cover to access the jumpers. Figure 2 shows jumper location.

### 5.1 Address Jumpers

Each module can have 1 of 16 addresses (00 to 33, Base 4). The address is factory set to 00. Figure 2 shows the location of the address jumper block. Table 3 lists the jumper settings for each address.

TABLE 3. Address Jumpers				
Address	Pins			
	1-8	2-7	3-6	4-5
00	c	c	c	c
01	c	c	c	nc
02	c	c	nc	c
03	c	c	nc	nc
10	c	nc	c	c
11	c	nc	c	nc
12	c	nc	nc	c
13	c	nc	nc	nc
20	nc	c	c	c
21	nc	c	c	nc
22	nc	c	nc	c
23	nc	c	nc	nc
30	nc	nc	c	c
31	nc	nc	c	nc
32	nc	nc	nc	c
33	nc	nc	nc	nc

c = connected    nc = not connected

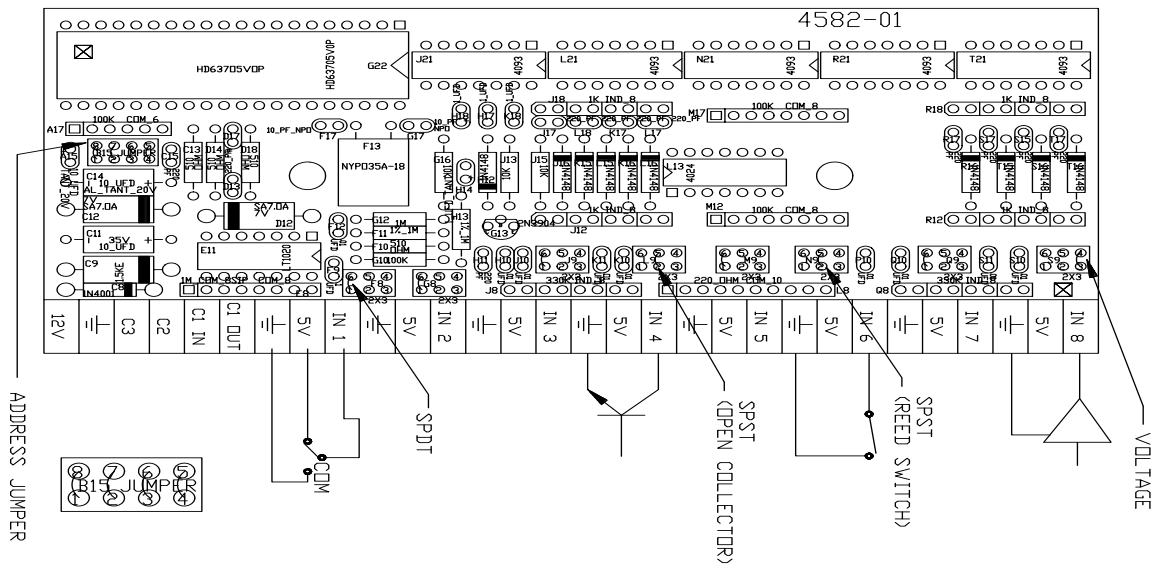


FIGURE 2. SDM-SW8A Address and Port Configuration Jumpers with Sensor Wiring Examples

## 5.2 Measurement Jumpers

Near each input channel is a jumper triplet used to configure the channel for the measurement type. The SDM-SW8A is shipped from the factory with each channel configured for DC Voltage pulse. An example of each configuration is illustrated in Figure 2. Table 4 shows jumper pins and the corresponding measurement type.

<b>Measurement Type</b>	<b>Pins Jumpered</b>
SPDT Switch Closure	1 and 6
SPST Switch Cl. or Open Coll.	2 and 5
Voltage Pulse	3 and 4

## 6. Datalogger Programming

The datalogger is programmed using either CRBasic or Edlog. Dataloggers that use CRBasic include our CR800, CR850, CR1000, CR3000, and CR5000. Dataloggers that use Edlog include our CR7, CR10(X), CR23X, and 21X. Both CRBasic and Edlog are provided in PC400 and LoggerNet datalogger support software.

### 6.1 CRBasic Programming

#### 6.1.1 SDMSW8A Instruction

The SDMSW8A instruction is used to control the SDM-SW8A Eight-Channel Switch Closure module, and store the results of its measurements to a variable array.

<b>Parameter &amp; Data Type</b>	<b>Enter</b>
<b>Dest</b> <i>Variable or Array</i>	The variable in which to store the results of the SW8A measurement. The variable array for this parameter must be dimensioned to the number of Reps.
<b>Reps</b> <i>Constant</i>	The number of channels that will be read on the SW8A. If (StartChan + Reps - 1) is greater than 8, measurement will continue on the next sequential SW8A. In this instance, the addresses of the SDM devices must be consecutive.
<b>SDMAddress</b> <i>Constant</i>	The address of the first SW8A with which to communicate. Valid SDM addresses are 0 through 15. If the SDMTrigger instruction is used in the program, address 15 should not be used. If the Reps parameter used more channels than are available on the first SW8A, the datalogger will increment the SDM address for each subsequent device that it communicates with.

Parameter & Data Type	Enter															
<b>FunctOp</b> <i>Constant</i>	The FunctOp is used to determine the result that will be returned by the SW8A.															
	<table border="1"> <thead> <tr> <th>Numeric Code</th> <th>Function</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>Returns the state of the signal at the time the instruction is executed. A 0 is stored for low and a 1 is stored for high.</td> </tr> <tr> <td>1</td> <td>Returns the duty cycle of the signal. The result is the percentage of time the signal is high during the scan interval.</td> </tr> <tr> <td>2</td> <td>Returns a count of the number of positive transitions of the signal.</td> </tr> <tr> <td>3</td> <td>Returns a value indicating the condition of the module:  <table border="1"> <tbody> <tr> <td><b>positive integer:</b></td> <td>ROM and RAM are good</td> </tr> <tr> <td><b>negative value:</b></td> <td>RAM is bad</td> </tr> <tr> <td><b>Zero:</b></td> <td>ROM is bad</td> </tr> </tbody> </table> </td> </tr> </tbody> </table>	Numeric Code	Function	0	Returns the state of the signal at the time the instruction is executed. A 0 is stored for low and a 1 is stored for high.	1	Returns the duty cycle of the signal. The result is the percentage of time the signal is high during the scan interval.	2	Returns a count of the number of positive transitions of the signal.	3	Returns a value indicating the condition of the module: <table border="1"> <tbody> <tr> <td><b>positive integer:</b></td> <td>ROM and RAM are good</td> </tr> <tr> <td><b>negative value:</b></td> <td>RAM is bad</td> </tr> <tr> <td><b>Zero:</b></td> <td>ROM is bad</td> </tr> </tbody> </table>	<b>positive integer:</b>	ROM and RAM are good	<b>negative value:</b>	RAM is bad	<b>Zero:</b>
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<b>positive integer:</b>	ROM and RAM are good															
<b>negative value:</b>	RAM is bad															
<b>Zero:</b>	ROM is bad															
<b>StartChan</b> <i>Constant</i>	The first channel that should be read on the SW8A. If the Reps parameter is greater than 1, measurements will be made on sequential channels.															
<b>Mult, Offset</b> <i>Constant, Variable, Array, or Expression</i>	A multiplier and offset by which to scale the raw results of the measurement. See the measurement description for the units of the raw result; a multiplier of one and an offset of 0 are necessary to output in the raw units. For example, the <b>TCDiff</b> instruction measures a thermocouple and outputs temperature in degrees C. A multiplier of 1.8 and an offset of 32 will convert the temperature to degrees F.															

### SDMSW8A Example

The following program measures all eight channels of an SW8A and outputs a sample of the pulse count to a table once every minute.

```
'Program Declarations
Public SW8ACount(8)

'Data Table Declarations
DataTable (CountTab,1,1000)
  DataInterval (0,1,Min,10)
  Sample (8,SW8ACount(),FP2)
EndTable

'Main Program
BeginProg
  Scan (1,Sec,3,0)
    SDMSW8A (SW8ACount(),8,0,2,1,1.0,0)
    CallTable CountTab
  NextScan
EndProg
```

### 6.1.2 SDMSpeed Instruction

The SDMSpeed instruction is used to change the bit period that the datalogger uses to clock the SDM data. Slowing down the clock rate may be necessary when long cable lengths are used to connect the datalogger and SDM devices.

The syntax of this instruction is as follows:

SDMSpeed ([BitPeriod](#))

The BitPeriod argument can be an integer or a variable. If the SDMSpeed instruction is not in the program, a default bit period is used. If 0 is used for the argument, the minimum allowable bit period is used. Table 5 shows the default, minimum allowable, and maximum bit period for each of our CRBasic dataloggers.

<b>Datalogger</b>	<b>Default Bit Period</b>	<b>Minimum Allowable Bit Period</b>	<b>Maximum Bit Period</b>
CR800, CR850	26.04 $\mu$ sec	8.68 $\mu$ sec	2.2 msec
CR1000	26.04 $\mu$ sec	8.68 $\mu$ sec	2.2 msec
CR3000	26.04 $\mu$ sec	8.68 $\mu$ sec	2.2 msec
CR5000	30 $\mu$ sec	8 $\mu$ sec	3 msec

The equation used to calculate the bit rate depends on the datalogger used. The datalogger will round down to the next faster bit rate.

Equation for CR800, CR850, and CR1000:

$$\text{bit\_rate} = \text{INT}((k * 72) / 625) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution=8.68 microseconds

Equation for CR3000:

$$\text{bit\_rate} = \text{INT}((k * 144) / 625) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution= 4.34  $\mu$ sec.

Equation for CR5000:

$$\text{bit\_rate} = \text{INT}(k * 20) * \text{Resolution}$$

Where:

k= the value entered in BitPeriod

Resolution=50 nsec.

## 6.2 Edlog Programming

Instruction 102, Table 6, is used to address and retrieve information from the SW8A.

TABLE 6. Instruction 102 - SDM-SW8A		
Parameter Number	Data Type	Description
01:	2	Repetitions
02:	2	Module Address (00..33)
03:	2	Function Option (0=State, 1=Duty 2=Counts, 3=Signature)
04:	2	SDM-SW8A Starting Channel (1..8)
05:	4	Starting input location for results
06:	FP	Mult
07:	FP	Offset

### NOTE

Instruction 102 is not contained in all CR10 or 21X PROMS. To verify that the datalogger contains the Instruction, enter 102 into a datalogger Programming Table. If the Instruction is accepted, the PROM contains the Instruction.

Repetitions (Reps, **Parameter 1**) specifies the number of SW8A channels to read. **Parameter 2** is the address of the first SW8A. If more Reps are requested than exist in one module, the datalogger automatically increments the address and continues to the next SW8A. The address settings for the SW8As must be sequential. For example, assume two SW8As with addresses of 22 and 23 are connected, and 12 Reps are requested. Eight channels from the first SW8A and the first four channels from the next will be read.

Only one Function Option (**Parameter 3**) may be specified per Instruction. If all four functions are desired, four Instructions must be entered in the datalogger program.

**Function Option 0** provides the **state** of the signal at the time 102 is executed. A 1 or 0 corresponds to high or low states, respectively.

**Function Option 1** provides signal **duty cycle**. The result is the percentage of time the signal is high during the sample interval.

**Function Option 2** provides a **count** of the number of positive transitions of the signal.

**Function Option 3** provides the **signature** of the SW8A PROM. A positive number (signature) indicates the PROM and RAM are good, a zero (0) indicates bad PROM, and a negative number indicates bad RAM. Function Option 3 is not used but is helpful in "debugging." Only one Rep is required for Option 3.

**Parameter 4** specifies the first SW8A channel to be read (1..8). One or more sequential channels are read depending on the Reps. To optimize program efficiency, the sensors should be wired sequentially.

Data are stored in sequential datalogger input locations, starting at the location specified in **Parameter 5**.

The number of input locations consumed is equal to the number of Reps.

The scaling multiplier and offset (**Parameters 6 and 7**) are applied to all readings. Enter 1 for the multiplier if no scaling is desired.

If the SW8A does not respond, -99999 is loaded into input locations. Modules which do not respond when addressed by the datalogger are possibly wired or addressed incorrectly. Verify that the address specified in Parameter 2 corresponds to the jumper setting and that all connections are correct and secure.

An example program for reading state, duty cycle, and counts of all 8 ports in a Module with an address of zero (0) is given in the Appendix.

## 7. Datalogger Program Details

### 7.1 Datalogger Scan Rate

The Module samples channel state every 2 ms and accumulates the information for duty cycle and counts. Each channel has one 16 bit accumulator for duty cycle and one for counts. The accumulators are reset when the datalogger requests information from the SW8A and when the count exceeds 65535. The datalogger scan rate must be frequent enough to avoid SW8A accumulator overflow.

Each Duty Cycle accumulator resets every 131 seconds ( $2 \text{ ms} * 65536$ ) or roughly 2 minutes. If Duty Cycle is requested, the datalogger scan rate must be less than 131 seconds.

The rate at which Count accumulators are reset is input frequency dependent. For example, at a maximum input frequency of 100 Hz, the datalogger must sample the SW8A at least every 655 seconds (approximately 10 minutes) or the accumulator for that channel resets and starts over again.

### 7.2 First Scan

From the time power is applied, the SW8A samples the state of all channels every 2 ms. The first time the datalogger executes Instruction 102 and requests information, the results represent the time period since the SW8A was powered up, not the datalogger scan interval. This problem may be avoided by ignoring the data from the first scan after the datalogger is compiled. The example program (see Appendix) includes a routine which discards first scan data.

## 7.3 Watchdog Reset

Any microprocessor may occasionally fail due to input transients or intermittent component failure (e.g., a bombed condition). The SW8A has a "watchdog" counter which resets the processor under such conditions. When functioning normally, the processor resets the watchdog counter. To transfer data between the datalogger and the SW8A, the datalogger drives the clock line, Control Port 2, high and low (refer to Theory of Operation, Section 9). The watchdog counts clock line transitions, and if the count exceeds 64, the watchdog resets the SW8A processor. Requesting State produces 16 clock transitions. Duty Cycle and Count each produce 24 + 16 clock transitions per channel.

The length of time that the SW8A stays bombed before a watchdog reset occurs is a function of the datalogger scan rate and the amount of information requested from the Module. For example, if the datalogger scan rate is 10 minutes, and 2 channels of counts are requested, the SW8A may stay bombed for 20 minutes. To avoid this undesirable time delay before resetting, a trapping routine may be programmed into the datalogger to detect a bombed condition and immediately force a watchdog reset.

When the module is bombed, NaN is stored in variables for CRBasic dataloggers, and -99999 is stored in input locations for Edlog dataloggers. When NaN or -99999 is detected, the trapping routine immediately forces a watchdog reset by addressing the Module and requesting sufficient information to cause a minimum of 65 clock line transitions. Advantages to using a trapping routine are:

- The bombed processor is detected before erroneous values (NaN or -99999) are included in subsequent processing.
- The processor may be reset sooner.
- The time of processor failure may be logged by the datalogger.
- Number of failures may be logged.

A CRBasic example of this trapping routine is shown below.

A trapping routine using Edlog is included in the example program in Appendix A.

```

'Program name: C:\Documents and Settings\nigel\My Documents\Customers\INBO\SDM-SW8A BOMB.CRI
'Date written: 13/07/2010

,
' Declare array of flags
Public Flag(9) As Boolean

'////////////////////// DECLARATIONS ////////////////////////

Public state(8)
Public duty(8)
Public counts(8)
Public RESETCNT

'////////////////////// OUTPUT SECTION ////////////////////////
DataTable(Table003,true,-1)
  OpenInterval
  DataInterval(0,5,Min,10)
  Sample(8, state, FP2)
  Average(8, duty, FP2,Flag(9))
EndTable

'////////////////////// SUBROUTINES ////////////////////////
Sub Subroutine1
  SDMSW8A(state,8,0,0,1,1,0)
  SDMSW8A(duty,8,0,1,1,1,0)
  SDMSW8A(counts,8,0,2,1,1,0)
EndSub

'////////////////////// PROGRAM ////////////////////////
BeginProg
  Scan(1,Sec, 3, 0)
  Call Subroutine1
  'If SDM-SW8A was just programmed or its processor is bombed, set intermediate processing disable Flag
  If Flag(1) = False Then Flag(9) = True      'Set Flag 9
  If (state(1) < 0) Then Flag(9) = True      'Set Flag 9
  ' Output state and average duty cycle every 5mins
  CallTable Table003
  ' start trapping routines
  ,
  If Flag(9) = True Then
    If Flag(1) = True Then
      ' reset routine
      Call Subroutine1
      RESETCNT = RESETCNT + 1
      Flag(1) = False
    Else
      Flag(1) = True
    EndIf
  EndIf
  NextScan
EndProg

```

## 8. Measurement Applications

### 8.1 SPDT Switch Closure

Single-pole double-throw switches may be found on some flow or volume sensors such as Watt-hour and water meters. The positive throw is connected to the 5 V terminal located next to the input channel, providing a 5 V bias for the SW8A to discriminate between throws. Similarly, the negative throw is connected to a ground terminal (refer to Figure 2, SPDT wiring example). When contact is made to the positive throw, SW8A circuitry holds a high state (5 V). When contact is made with the ground throw, a low state is maintained (0 V). Switch bounce may occur any number of times at a throw, but until contact is made with the opposite throw, a change in state will not occur. The pole must make contact with the throw for 3 ms for a state change to occur. Figure 3 illustrates a raw SPDT signal in relation to the signal conditioned by the SW8A.

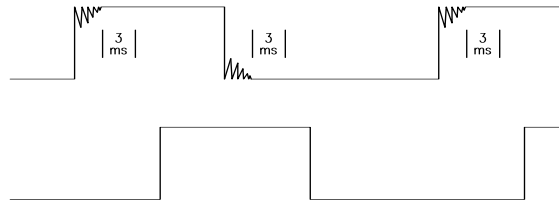


FIGURE 3. SPDT Signal Conditioning by SDM-SW8A

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#### NOTE

The 5V output located next to each of the 8 input channels is for biasing in the SPDT measurement. A 200 Ohm resistor is in series to protect against accidental shorting to ground.

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### 8.2 SPST Switch Closure

Single-pole single-throw switches are either open (high state) or connected to ground (low state). Typical SPST switches include contact closure (reed switch) anemometers, tipping bucket rain gauges, and open collectors (semiconductor switches). Many control devices utilize open collectors and provide terminals for monitoring the switch.

For all SW8A measurements, the 100 Hz maximum input frequency and 5 ms pulse width specifications must be taken into consideration. To illustrate, consider the Met-One 014A Cup Anemometer which is an SPST-type sensor. The 014A calibration is:

$$\text{MPH} = 1.789 * f + 1$$

where: MPH = miles per hour  
f = pulse frequency in Hz

The 100 Hz maximum input frequency to the SW8A equates to 180 MPH. The duty cycle of the 014A as measured by the SW8A is 35%. A 5 ms pulse

width becomes a limitation at 70 Hz (0.35/0.005sec), or about 126 MPH. The SW8A's maximum input frequency and 5 ms minimum pulse width specifications are not a limitation given the 014A's maximum calibrated speed of 100 MPH.

### 8.3 DC Voltage Pulse

Voltage pulse transitions from below 0.9 V to above 4.0V, not exceeding  $\pm 20V$ , with a minimum pulse width of 5ms, are counted accurately at any frequency less than or equal to 100 Hz.

### 8.4 Duty Cycle

Duty cycle is not an exact measurement due to the SW8A input filtering and 2 ms sampling frequency. Signal magnitude also affects duty cycle measurements. Optimum duty cycle measurements result if an integral number of cycles are measured per datalogger scan interval, and the scan interval is at least 1 second.

**Input Filtering and Sample Frequency Error** - In a "worst case" analysis, input filtering will distort the time that the signal is high by  $\pm 2.5$  ms. If the input filtering is at worst case, the 2 ms sampling frequency can create an error of  $\pm 2$  duty cycle samples on any measurable cycle.

Equations given below estimate the "worst case" duty cycle measurement error for a 50% duty cycle and the minimum/maximum measurable duty cycle for a given frequency. The error limits are calculated, assuming a sample interval of a single cycle. The error may be significantly reduced by allowing the SW8A to measure duty cycle over several cycles. As shown by the equations, the error decreases with decreasing frequency.

**50% Duty Cycle** - The "worst case" duty cycle measurement error for a 50% duty cycle at a given input frequency is

$$\pm \text{ERROR} = \text{Hz} * 0.4$$

where  $\text{ERROR} = \text{Actual Duty Cycle} \pm \text{Measured Duty Cycle}$ .

For example, a 50% duty cycle at 10 Hz could be measured as 46% to 54% in the worst case.

**Minimum/Maximum** - The measurable minimum/maximum duty cycle is defined by the 5 ms pulse width specification of the SW8A. For example, at a 10 Hz frequency, the minimum and maximum duty cycle that can be measured is 5% and 95%, respectively (0.005/0.100 \* 100). The "worst case" duty cycle measurement error for the minimum/maximum measurable duty cycle is

$$\pm \text{ERROR} = \text{Hz} * 0.3$$

For example, the minimum measurable duty cycle for a 1 Hz signal is 0.5%. The duty cycle measurement could range from 0.2% to 0.8%.

**Signal Magnitude** - The signal magnitude should range from 0 - 0.9 V low, to 4 - 5 V high, or the signal should be centered around 2.5 V with a minimum 8 V peak to peak magnitude. When the magnitude is 0 V to greater than 5 V, the wave form begins to distort, resulting in less accurate duty cycle information.

## 9. Theory of Operation

The Switch Closure Input Module uses a 63705 microprocessor to sample the 8 ports and communicate with the datalogger. The processor is in a low power "Wait" mode except when interrupted.

An internal timer interrupts the processor approximately every 2 milliseconds to sample the input ports. At this time, for each port, the duty cycle accumulator is updated, and the transition counter is incremented if the state represents a positive transition from the previous state.

C3, driven high by the datalogger, also interrupts the SW8A. The SW8A prepares to receive an 8 bit byte (consisting of address in the most significant nibble and command in the least significant nibble with the least significant bit always a 1) from the datalogger. The datalogger drives C2 as a clock line and C1 as a serial data out line. The datalogger shifts out each bit (LSB first) on the falling edge of the clock; the Switch Closure Module shifts in each bit on the rising edge of the clock.

When all 8 bits are received by the SW8A, the SW8A is again interrupted by its serial communication interface. If the address part of the byte received equals the jumpered address, the SW8A executes the command part, providing it is valid. For Function Options 1 and 2, the module receives another byte containing Reps and Channel information from the datalogger. For a valid address and command, the SW8A prepares to return a code byte as acknowledgment to the datalogger. Except for the 21X, the datalogger switches C1 to an input and after 2 milliseconds clocks back the code byte from the SW8A. If the code byte is correct, the datalogger knows the addressed SW8A is present. The 21X works similarly, except the data from the SW8A is input to single ended analog channel 1, not C1.

Depending on the Command, Reps, and Channel information, the module will shift out one or more bytes to the datalogger, again using C2 as a clock driven by the datalogger. The module shifts out each bit on the falling edge of the clock; the datalogger reads each bit on the rising edge of the clock.

Each time an entire byte is transmitted to the datalogger, the SW8A is interrupted and prepares to send the next byte, if any. When all requested bytes have been sent, the SW8A disables its serial communication interface and waits for both C3 and C2 to be driven low by the datalogger. When this happens, the SW8A prepares again to start a new command cycle.

An important feature of the module is its watchdog counter. The counter pulls the processor momentarily into reset if the count gets too high. The counter counts the C2 clock transitions. Under normal operating conditions, the processor resets the counter. If the processor is "bombed," it will not reset the counter. As the datalogger makes requests of the Switch Closure Module, the counter increments to the point where it resets the processor; the module will then start operating correctly again.



# Appendix A. Edlog Program Example

The Edlog program is an example only and is not meant to be used verbatim. In application, the concepts illustrated here are likely to be only fragments of a larger program.

The example program reads all 8 ports of an SW8A which is set to address 00. It is read three times per scan, once each for State, Duty Cycle, and Count information. The scan rate is fixed at 1 second, with a 5 minute output of State, average Duty Cycle, and average Count.

To prevent erroneous values from being included in Output Processing routines, the datalogger's Intermediate Processing Disable Flag (Flag 9) is set under the following two conditions.

1. **When the SW8A is not responding** - If the processor is not responding, a value of -99999 is detected in the first Location containing SW8A data, and Flag 9 is set high. The SW8A is accessed a second time to increment the watchdog counter to greater than 64 and force a watchdog reset (refer to Section 7.3). A RESET COUNTER (input location 25, RESET CNT) is incremented and output with time to create a record of when and how many times the SW8A has been reset since the last datalogger compilation.
2. **When the current scan is the first scan after compiling the datalogger program** - If the datalogger program is compiled in the \*0 Mode, all Flags are set low following compilation. To detect the first scan after the datalogger is compiled, the state of user Flag 1 is checked. If Flag 1 is low the Intermediate Disable Flag (Flag 9) is set high to prevent the first readings from being included in subsequent Output Processing Instructions. Flag 1 is set high at the end of the first scan.

A flow chart of the example program is presented in Figure A-1.

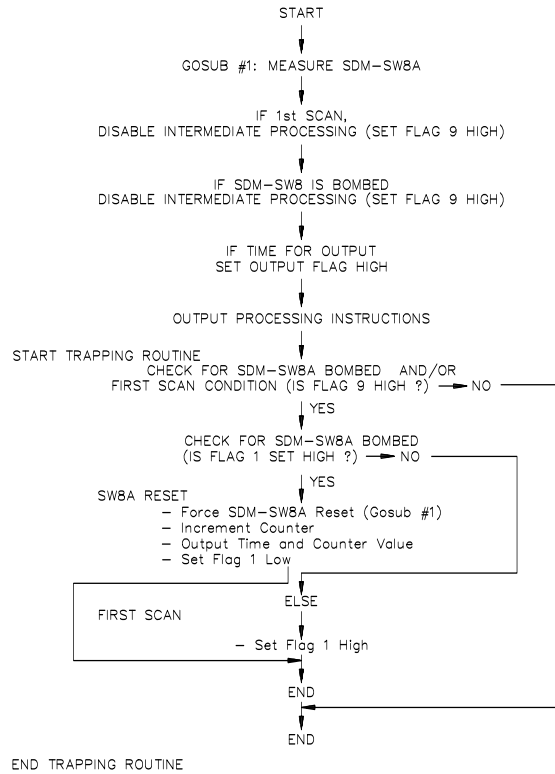


FIGURE A-1. Example Program Flow Chart

**PROGRAM EXAMPLE**

<b>Input Locations Used:</b>	
1:STATE #1	13:DUTY #5
2:STATE #2	14:DUTY #6
3:STATE #3	15:DUTY #7
4:STATE #4	16:DUTY #8
5:STATE #5	17:COUNT#1
6:STATE #6	18:COUNT #2
7:STATE #7	19:COUNT #3
8:STATE #8	20:COUNT #4
9:DUTY #1	21:COUNT #5
10:DUTY #2	22:COUNT #6
11:DUTY #3	23:COUNT #7
12:DUTY #4	24:COUNT #8
	25:RESET CNT
<b>Output Arrays:</b> ID = 105, 27 ELEMENTS	
	ID = 112, 4 ELEMENTS
105, DAY, HRMN, STATE #1,... STATE #8, DUTY #1, ... DUTY #8, COUNT #1, ... COUNT #8	
112, DAY, HRMN, RESET COUNT	

## \*Table 1 Programs

01: 1            Sec. execution interval

## 1: Do (P86)

1: 1            Call Subroutine 1

*If SDM-SW8A was just programmed or its processor is bombed, set intermediate processing disable flag.*

## 2: 1 If Flag/Port (P91)

1: 21            Do if flag 1 is low

2: 19            Set Intermed. Proc. Disable Flag High (Flag 9)

## 3: If X&lt;=&gt;F (P89)

1: 1            X Loc state #1

2: 4            <

3: 0            F

4: 19            Set high Flag 9

*OUTPUT STATE AND AVERAGE DUTY CYCLE EVERY 5 MINUTES.*

## 4: If time is (P92)

1: 0            minutes into a

2: 5            minute interval

3: 10           Set high Flag 0 (output)

## 5: Real Time (P77)

1: 110          Day,Hour-Minute

## 6: Sample (P70)

1: 8            Reps

2: 1            Loc state #1

## 7: Average (P71)

1: 16           Reps

2: 9            Loc duty #1

## \*\*\*\*\* START TRAPPING ROUTINES \*\*\*\*\*

## 8: If Flag/Port (P91)

1: 19            Do if flag 9 is high

2: 30            Then Do

## 9: If Flag/Port (P91)

1: 11            Do if flag 1 is high

2: 30            Then Do

## \*\*\*\*\* RESET ROUTINE \*\*\*\*\*

*To force a watchdog reset, increment reset counter, output time and number of resets, and set flag 1 low.*

```

10: Do (P86)
  1: 1      Call Subroutine 1

11: Z=Z+1 (P32)
  1: 25     Z Loc [:RESET CNT]

12: Do (P86)
  1: 10     Set high Flag 0 (output)

13: Real Time (P77)
  1: 110    Day,Hour-Minute

14: Sample (P70)
  1: 1      Reps
  2: 25     Loc RESET CNT

15: Do (P86)
  1: 21     Set low Flag 1

***** FIRST SCAN ROUTINE *****

16: Else (P94)

17: Do (P86)
  1: 11     Set high Flag 1

18: End (P95)

19: End (P95)

20: End Table 1

*Table 3 Subroutines

** SUBROUTINE TO MEASURE SDM-SW8A **

1: Beginning of Subroutine (P85)
  1: 1      Subroutine Number

2: SDM-SW8A (P102)
  1: 8      Reps
  2: 00     Address
  3: 0      Channel state(s) function
  4: 1      Chan
  5: 1      Loc [:state #1 ]
  6: 1      Mult
  7: 0      Offset

```

```
3: SDM-SW8A (P102)
  1: 8      Reps
  2: 00     Address
  3: 1      Duty cycle function
  4: 1      Chan
  5: 9      Loc [:duty #1 ]
  6: 1      Mult
  7: 0      Offset

4: SDM-SW8A (P102)
  1: 8      Reps
  2: 00     Address
  3: 2      Counts function
  4: 1      Chan
  5: 17     Loc [:counts #1]
  6: 1      Mult
  7: 0      Offset

5: End (P95)

6: End Table 3
```





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