

# ***GMON3 Snow Water Equivalency Sensor***

## ***User Guide***

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# PLEASE READ FIRST

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## 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:

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



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## Cautions / Safety Notes

- If you are unable to determine that your structure or mounting method is suitable for the GMON3 sensor, please contact an expert or professional who can assist you in determining the structural mounting requirements for your installation of the GMON3.
- Always ensure that the collimator is secured to the structure with the long safety cable.
- Do not disassemble the GMON3 without consulting the factory first. The GMON3 contains a fine bead-like insulation material called Aerogel Nanogel. The material is manufactured by Cabot Corporation. Proper MSDS sheets and instructions should be obtained prior to opening the GMON3.
- The collimator is heavy and proper handling procedures need to be followed when handling the part.
- Never force the connector on to the GMON3. If the connector does not easily fit into place then it is likely misaligned.

## Abbreviations/Syntax

<b>K</b>	The Element Potassium
<b>SWE</b>	Snow Water Equivalency
<b>Tl</b>	The Element Thallium
<b>[]</b>	Square brackets identify a typed command. The content inside the brackets is what is sent or typed and the brackets are excluded.
<b>&lt;&gt;</b>	Denotes a special key for example <Enter> represents the Enter Key.



# ***GMON3 Snow Water Equivalency Sensor***

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## **1. Introduction**

The GMON3 Sensor is primarily designed to measure the SWE (Snow Water Equivalency) in a snow pack. The name GMON3 is derived from an abbreviation of “Gamma MONitor”.

The GMON3 obtains a measurement by monitoring gamma rays that are naturally emitted from the ground. As snow accumulates on top of the ground the GMON3 measures a decrease in the normal background radiation levels. The higher the water content the higher the attenuation of the gamma radiation.

The GMON3 has several characteristics that make it an excellent sensor for SWE measurement applications.

- The sensor is non-contact. It is installed simply by mounting it above the snow surface.
- Its performance is not affected by adverse weather conditions.
- The Sensor’s measurement covers a large surface area. Typically 50 to 100 Square Metres (538 to 1076 Square Feet) when mounted 3.0 Metres above the ground.
- It is effective with any type of snow or ice.

Proper operation of the GMON3 is dependent on suitable amounts of Gamma radiation emitted by the ground. Potassium and Thallium are 2 of the elements that will produce the required Gamma radiation. Since the radiation levels will vary from site to site, the GMON3’s performance can also be site specific.\*

\*The GMON3 only monitors existing naturally occurring Gamma radiation. No special licenses or precautions are required to install or operate the GMON3.

## **2. Specifications**

Power Requirements:	11 to 15V DC
Power Consumption:	180 mA
Measurement Time:	Continuous, 24 hours/day
Output Format:	RS-232 (1200 to 115200 bps) Default is 9600 bps
Measurement Range:	0 to 600 mm (0 to 23.6 in) of Water Equivalency

Accuracy:	±15 mm (±0.6 in) for 0 to 0 to 300 mm (11.8 in) ±15% at 300 to 600 mm (11.8 to 23.6 in)
Resolution:	1 mm (0.004 in)
Coverage Beam Angle:	60°
Operating Temperature:	-40° to +40°C
Maximum Cable Length:	30 m (95 ft) (9600 BAUD or less)
Cable Type:	4 conductor, 2-twisted pair, 22 AWG, Santoprene jacket
Dimensions (Without Collimator):	Length: 62 cm (24.4 in) Diameter: 12.7 cm (5 in)
Weight:	
Main Body:	9.0 kg (20 lbs)
Collimator:	25 kg (55 lbs)
Total:	34 kg (75 lbs)

### 3. Wiring

The wiring for the GMON3 connector-cable assembly is as follows:

Colour	Function	Connection
Black	Power Ground	System Ground and/or RS-232 Receiver Ground (Pin 5 of a computer (DTE) DB-9 connector)
Red	+12VDC Power	Power Source
Green	RS-232 (Sensor Output)	Recorder/Reader RS-232 Input (Pin 2 of a computer (DTE) DB-9 connector)
White	RS-232 (Sensor Input)	Recorder/Reader RS-232 Output (Pin 3 of a computer (DTE) DB-9 connector)
Clear	Shield	Shield/Earth Ground

### 4. Connecting the GMON3 to a Computer

The GMON3 can communicate directly to PC using a terminal program such as Hyperterminal. To provide a DB9 connection between the GMON3 and a PC's RS-232 port, the DB9F-TERM interface PCB is used. The DB9F-TERM is shipped with the GMON3. The following diagram demonstrates how to connect the GMON3 to the DB9F-TERM.

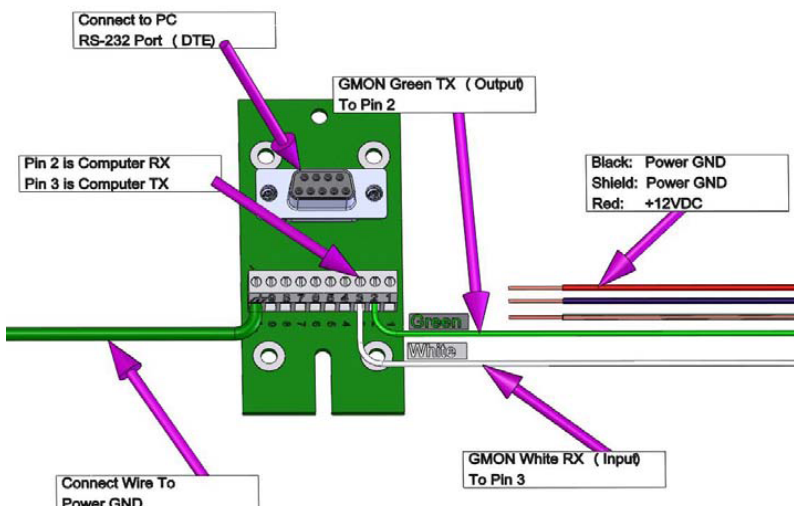


Figure 1. GMON3 connection to DB9F-TERM

When connecting the GMON3 to a computer a power source is required to power the GMON3. A good quality regulated +12V DC power source should be used such as a bench power supply or a +12V DC battery. It is recommended to disconnect the cable from the GMON3 while terminating the cable connections. After the connections are verified, the connector can be reconnected to the GMON3.

## 5. Terminal Setup for RS-232 Communications

The following are the settings required for the terminal program to communicate with the GMON3. Typical programs include Hyperterminal or Procomm.

BAUD Rate:	9600 (Default)
Data Bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	None
Local Echo:	Enabled
Terminal Mode:	ANSI
Send Line Ends with Line Feeds:	Disabled

When the power is applied to the GMON3 or the connector is plugged in the GMON3 will output the following message on the RS-232 port on power up:

GMONIII Scionix 3x3 V4f\_13u SN: 9999

Where:

GMONIII:	Is the sensor Identifier (GMONIII is the 3rd Generation technology)
Scionix 3x3:	Is the Gamma Detector Type
V4f_13u:	Is the Firmware Software Revision
SN:	9999 Is the sensor's serial number

## 6. Communicating with the GMON3

### 6.1 General

Immediately after power on, the GMON3 will default to a baud rate defined by the "DefaultBaudRate" parameter. This is normally 9600 BAUD and it is recommended to leave the setting at 9600 BAUD.

The Escape key resets the current command line being entered into the GMON3. If you are communicating with the GMON3 using another intelligent device, the commands should be preceded with the ESC character to ensure more reliable operation.

The Commands to the GMON3 are case sensitive.

All commands are terminated by the Enter key or <CR> character.

### 6.2 Auto BAUD Rate Detection

If the terminal speed does not match the GMON3's baud rate, the startup message will either be absent or garbled. The GMON3 does support an Auto BAUD Rate Detection feature. In order to synchronize the GMON3 with the terminal, one can type the letter 'U' in uppercase followed by a period "." and a carriage return. This will trigger the auto-baud system, and the GMON3 will adjust its baud rate to the baud rate of the terminal. The period "." followed by a carriage return (CR) launches the Main menu once the BAUD Rates are synchronized.

#### NOTE

---

Any changes to the GMON baud rate must be accounted for in the datalogger program.

---

### 6.3 Main GMON3 Menu

The Main menu can be prompted by sending a period "." followed by the Enter key

.<Enter>

The Menus can be switched between English and French. To change the language setting, key the command .L<Enter>. This will allow the selection of either English or French. The English version of the Main menu is as follows:

\*\*\* LIST OF COMMANDS \*\*\*

[.L]	Language
[.h]	Read the current live histogram
[.hp]	Display the K and Tl peak positions from the live histogram

[.hl]	Display the current histogram in log scale
[.e]	Same as <h> command , but erases histogram at end of operation
[.a]	Special command: define start/stop time limits for one measurement
[.t]	Display temperature sensors (detector and electronics)
[.d]	Display date and time
[.dd]	Modify date and time
[.H]	Read back histograms from EPROM according to selected dates
[.F]	Read back measurement results from EPROM according to selected dates
[.Fl]	Read back last measurement results
[.Fs]	Read back last results in short form (Time and SWEs only)
[.P]	Display Parameter Menu
[.S]	Display status and current measurement information
[.Oxw]	Start the program upload function
[.Rsoft]	Restart the GMON software
[%Rhard]/[%Rboot]	Restart software processor/Reboot firmware
[.Edata]	Delete all histograms and results from EPROM

## 6.4 Detailed Main Menu Command Information

### 1. [.L]

The [.L] command is used to set the language setting to either French or English.

The following menu is activated once the [.L] command is received:

```
[0] Francais
[1] English
```

Type the number 0 for French or the number 1 for English followed by <Enter>.

### 2. [.h]

The [.h] command is used to obtain the current histogram results. This information would normally be used for diagnostics or by a user who requires an analysis of the gamma radiation spectrum. The counts for 1024 bin values are returned in this command. The format is as follows:

```
12<CR><LF> This line represents the counts for BIN#1
345<CR><LF> This line represents the counts for BIN#2
333<CR><LF> This line represents the counts for BIN#3
.
.
.
30<CR><LF> This line represents the counts for BIN#1024
```

### 3. [.hp]

The [.hp] command is used to obtain the current bin positions for the Tl and K peaks. In general the Tl peak should be near 438 and the K peak should be near 245. It is important for the software to find the peaks properly in order to obtain proper SWE measurements.

In most cases the sensor must be monitoring for at least 2 minutes. It may take as long as a full hour if the radiation counts are very low.

Once the command is typed the following is immediately displayed:

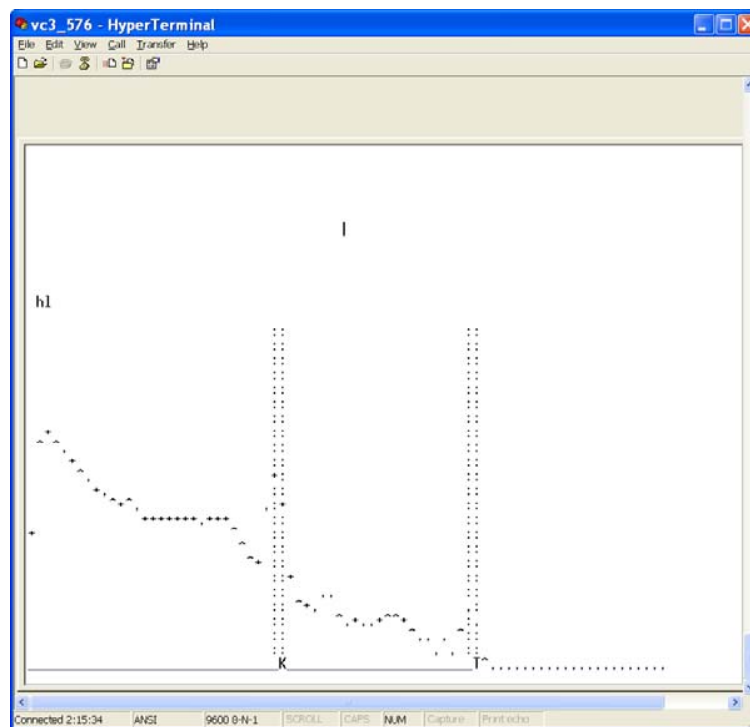
This operation may take 1-2 minutes

Once the calculation has been completed the values are displayed. Even under ideal conditions the values are allowed to vary from the target values. If the value does vary by more than 30 BINS then there may be issues with the sensor finding the proper peaks. The displayed values are formatted as follows:

Tl (nom = 438)	K (nom = 245)
435.4	244.7

#### 4. [.hl]

The [.hl] command is used to obtain a graphical representation of the current histogram results. This information would normally be used for diagnostics or by a user who requires an analysis of the gamma radiation spectrum. The command produces a log scale graph as follows:





## 5. [.hr]

The [.hr] command is used to verify radiation counts in manual mode. The [.hr] command would normally be used in the process of qualifying a site for adequate background radiation counts and is used in conjunction with the [.a] command. See the [.a] command for details.

Please note that the [.hr] command can take several minutes to complete. When the command is entered the [.hr] command will immediately report the duration of the current manual count time as follows:

-Elapsed time,current histo : 00:03:59 (HH:MM:SS)

There will then be a pause that can take several minutes. After the pause a histogram will be output followed by the radiation count summary. The summary will report 3 lines; the duration of the counting, the position of the Potassium peak and its processed count value, the position of the Thallium peak and its processed count value. The output format after the histogram is as follows:

-Elapsed time,current histo : 00:03:59

Pos K = 240.4; Pos Tl = 427.5;

Cnt K = 003679.8; Cnt Tl = 000088.3;

## 6. [.e]

The [.e] command is the same as the [.h] command except that it erases the counts once completed. Normally this is used for diagnostics or factory calibration. The counts for 1024 bin values are returned in this command. See the [.h] command section for the output format.

## 7. [.a]

The [.a] command is used to set the start and stop times for a specified measurement interval. This command could be used in the process to qualify a site for appropriate amounts of background radiation.

It is recommended that the GMON3 be placed in Manual mode by entering the Parameter Menu [.P] and set parameter 19 to 1 for Manual mode.

Once the parameter is set (the setting will be saved automatically) use the .a command to specify the delay and duration in seconds. For qualifying a site we recommend that the sensor be setup in the desired location and the delay of 1 be used with a duration of 3600 seconds (1 Hour) as a minimum.

After completion the [.hr] command can then be used to view the results in detail.

8. [.t]

The [.t] command is used to read the internal temperature sensor of the GMON3 (degrees Celsius). This feature is mainly used for diagnostics. Temperature measurements are made inside of the internal electronics to apply temperature compensations. The temperature after the C: is the Crystal Temperature of the detector and the temperature after the E: is the electronics temperature. The output format is as follows:

C:23 E:27

9. [.d]

The [.d] command is used to display the current date and time. The display order is:

Day of Month/Month/Year <4 space characters>  
Hour:Min:Sec<CR><LF>

The format is as follows: 16/09/2009 15:00:20

The GMON3 does not perform any time zone or Daylight-Savings time correction. This can be done in the datalogger.

10. [.dd]

The [.dd] command is used to set the current date and time. The following menu is activated from the [.dd] command:

Modify that date? :  
[1] aaaa: 2009  
[2] mm: 09  
[3] jj: 16  
[4] hh: 15  
[5] mm: 01  
[6] ss: 54  
[.] Exit  
[99] Accept selection

To Modify: [parameter number, space, new value,CR]

The current values at the time the .dd command was entered are displayed. To change a value, enter the parameter number followed by the new value and then the Enter key. To change the minute to 02 from 01 one would enter the following:

5<Space>02<Enter>

When a new value is entered the menu will redraw and display the time that will be set once the 99 is entered to accept the selection.

The time should be set for the purpose of control and analysis of the data. It can be local time, GMT, or any other. The GMON3 does not perform any time zone or Daylight-Savings time correction.

## 11. [.H]

The [.H] command is used to Read back histograms from EPROM according to selected dates. When the [.H] command is entered the following menu is displayed:

Histograms: Select first day to retrieve

Modify that date? :

[1] aaaa: 2009

[2] mm: 09

[3] jj: 16

[.] Exit

[99] Accept selection

To Modify: [parameter number, space, new value,CR]

This is the first day that the historic histograms will be displayed from. Once the start date is entered and accepted the menu will prompt for an end date as follows:

Histograms: Select last day to retrieve

Modify that date? :

[1] aaaa: 2009

[2] mm: 09

[3] jj: 16

[.] Exit

[99] Accept selection

To Modify: [parameter number, space, new value,CR]

After the last day or end date is accepted the Histograms will be reported in the following format. For each day requested the date is placed first followed by the 1024 bin values.

```
22/09/2009 23:59:50  Time stamp of first requested day
29                  This line represents the counts for BIN#1
52                  This line represents the counts for BIN#2
67                  This line represents the counts for BIN#3
.
.
7                  This line represents the counts for BIN#1024
23/09/2009 23:59:50  Time stamp of second requested day
359                 This line represents the counts for BIN#1 for
                     the second day
```

## 12. [.F]

The [.F] command is used to Read back measurement results from EPROM according to selected dates.

Four lines will be output for every day requested where monitoring occurred. See the section under [.FI] for output details.

### 13. [.FL]

The [.FL] command is used to Read back the last 4 detailed measurement results. The output will consist of 4 lines as follows:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
01/10/2009	00:59:	1	2	52913	11342	5716	393	343	411	18	18	64	120	9	24	24	13	4.2	12.98
01/10/2009	06:59:	1	2	57037	13168	6074	371	309	392	18	18	77	110	7	19	24	13	4.2	12.23
01/10/2009	12:59:	1	2	69645	13016	6415	371	360	375	18	18	27	165	2	8	24	12	3.2	12.23
01/10/2009	18:59:	1	2	58951	14218	6280	359	292	382	18	18	83	032	1	16	24	13	3.2	12.23

The format is the date and time stamp followed by the following numbers:

1. Date and Time Stamp
2. Station ID
3. GMON3's Serial number
4. K counts total uncorrected
5. K counts total corrected (this value is used in the actual SWE calculations)
6. Tl counts total corrected (this value is used in the actual SWE calculations)
7. SWE value generated from K
8. SWE value generated from K and Tl
9. SWE value generated from Tl
10. Soil Moisture values generated from K
11. Soil Moisture values generated from Tl
12. Soil Moisture values generated from K and Tl
13. Precipitation index: Flag indication recent snowfall or rain
14. Detector temperature min
15. Detector temperature max
16. Total number of histogram blocks used for the analysis
17. Displacement of the K peak from its nominal position (in bins)
18. Statistical significance of the SWE Tl measurement
19. Power input voltage at the GMON3 (after protection diode drop)

### 14. [.Fs]

The [.Fs] command is used to Read back last results in short form. The short form consists of the Date and time of the readings and the SWE values in millimetres. The format is as follows:

DD/MM/YYYY HH:MM:SS SWE\_K SWE\_TL

01/10/2009 06:59:50 123 129

## 15. [.P]

The [.P] command is used to display the parameter setup menu. The parameter setup Menu is as follows:

[1] Station ID	: 001
[2] GMON3's serial number	: 002
[3] Time of start of measure (relative to GMON3 00h RTC)	: 01
[4] Delay after start of measure for data Xmission (secs.)	: 300
[5] XMitO6h flag: 0 => every 24 h 1 => every 6 h	: 1
[6] GMON3 height above ground in centimetres	: 300
[7] Observed position for the K line on the histogram	: 245
[8] Collim (1: Collimator installed; 0: no collimator)	: 1
[9] Nominal soil moisture in %	: 25
[10] HCalib; Measured soil moisture for auto calibration (%)	: 27
[11] n0Ke	: 230000
[12] n00Ke (residual Ke counting)	: 225
[13] n0Tl	: 41000
[14] n00Tl ( residual Tl counting)	: 1900
[15] PcPn in part par thousand	: 50
[16] SN Threshold for the snow cover	: 5
[17] Baud rate for scheduled transmissions	: 9600
[18] Number of hours per partial histo (hours),(1,2,3,or 6)	: 1
[19] Manual mode (1); Auto mode (0) ; HCalib mode (2);	: 0
[.] Quit menu	
[99] Save parameters on EPROM	

To modify: [parameter number, space, new value,CR]

**[1] Station ID**

This is a user selectable value that can be used to identify a GMON3. The Station ID is part of the output information for certain data formats. The value is an integer that ranges from 0 to 231 (2147483648).

**[2] GMON3's serial number**

This should reflect the serial number of the GMON3 sensor. This is for diagnostics and sensor identification. The serial number is an integer in the range of 0 to 2<sup>31</sup> (2147483648).

**[3] Time of start of measure (relative to GMON3 00h RTC)**

This defines the hour at which a 24-hour period of measurements will begin. This number is relative to the time set in the internal Real Time Clock (RTC) by the user. The format is an integer, with values from 0 to 24. This also defines the time a 24-hour measurement will end. This end time is 10 seconds before the start of measure.

**[4] Delay after start of measure for data Xmission (secs.).**

This defines the time at which the calculated results from the previous 24-hour period will be automatically transmitted from the serial port. It is recommended to set the value to zero in order to disable the Automatic transmission of data via the serial port.

This is in seconds after the start of the new 24-hour period. The minimum value should be 300, in order to allow the calculations to complete. The maximum value is 23h 55 minutes (86100 seconds) in the case of one transmission every 24 hours, and 5h 55min (21,300 seconds) in the case of one transmission every 6 hours. This option is set with parameter XMitO6hflag. There will be 4 transmissions spaced by 6 hours.

**[5] XMitO6h flag: 0 => every 24 h 1 => every 6 h**

This configures the Automatic Data output, and allows output every 24h or every 6h.

This parameter is a flag to instruct the software to transmit the calculated data once a day (value = 0), or once every 6 hours (value = 1). All data output configured with this parameter is relative to the “Time of start of measure” parameter.

It should be noted that the daily output transmission consists of four averaged values from four overlapping 24-hour periods, which are offset by 6 hour intervals.

When the every 6 hours mode is selected, the same four periods will be transmitted, but one at the time, as they become available.

**[6] GMON3 height above ground in centimetres**

Enter the actual installed height of the GMON3 above the ground. Measured from the bottom of the main body, not from the collimator. This is a parameter used in the SWE calculation to account for the absorption of gamma rays in air.

**[7] Observed position for the K line on the histogram**

This is a parameter used by the peak finding and identifying algorithm, in order to properly frame the search window. It is the bin position at which the 40K isotope peak is observed on the histogram. This is to allow for small shifts in the detector gain. The format is an integer with a value equal or close to 245.

**[8] Collim (1: Collimator installed; 0: no collimator)**

This parameter is for future use of the GMON3 without a collimator. Currently this option should not be changed as use of the GMON3 without a collimator is still experimental.

**[9] Nominal soil moisture in %**

The value (site specific) for the soil moisture is used to account for the amount of water in the soil. This quantity is defined for a unit volume of soil as

$$100 \text{ (mass of water/mass of dry soil)}$$

Once the soil is frozen, this quantity is relatively constant. The format is an integer between 0 and 100.

**[10] HCalib; Measured soil moisture for auto calibration (%)**

This is a site specific parameter used for the autocalibration of the GMON3. The auto calibration mechanism calculates baseline values for the coefficients n0Ke and n0Tl. These coefficients correspond to the integrated rates of gamma rays seen by the detector for the K peak (n0Ke) and the Tl peak (n0Tl) with zero moisture. The HCalib parameter is normally the moisture measured by some other means at the time of the calibration in order to account for this moisture in the soil when the parameters n0Ke and n0Tl are evaluated. The format is an integer.

**[11] n0Ke**

This site specific parameter is used in the calculation of the SWE. It represents the integrated gamma ray count rate for the Potassium 40K isotope peak, with no snow cover and dry soil. This number is of course dependent upon the level of natural radio-activity of the soil at the installation site. It can only be calculated on the site. The auto-

calibration method is a tool to obtain the first estimate of that parameter. The format is an integer.

**[12] n00Ke (residual Ke counting)**

This is a parameter to account for the gamma rays coming from above the surface of the snow. This is typically a very small number (~225), and affects the SWE evaluation only under very high SWE conditions (above 300 mm.). For most applications, the default value of 225 is satisfactory.

**Note:** This value should not be altered above 225 unless extensive site data analysis has been completed and Campbell Scientific has been consulted.

**[13] n0TI**

This site specific parameter is used in the calculation of SWE. It represents the integrated gamma ray count rate for the Thallium 208TI isotope peak, with no snow cover and dry soil. This number is of course dependent upon the level of natural radio-activity of the soil at the installation site. It can only be calculated on the site. The auto-calibration method is a tool to obtain the first estimate of that parameter. The format is an integer.

**[14] n00TI ( residual TI counting)**

This is a parameter to account for the gamma rays coming from above the surface of the snow. It affects the SWE evaluation only under high SWE conditions (above 300 mm.). For most applications, the default value of 1900 is satisfactory.

**[15] PcPn in part par thousand**

This parameter can be left as default. Its use is mainly experimental. The parameter is a threshold for the setting of the “precipitation flag” that appears in the detailed data output. The precipitation flag is set when the count rate from Bismuth isotopes increases by more than this factor over a period of 6 hours. The format is integer, in parts per thousand. The default value is 50.

**[16] SN Threshold for the snow cover**

This parameter is a threshold above which the normal calculation of the SWE will be performed. The threshold is applied to a calculation of the SWE based on the ratio of K/TI, which is independent of the humidity of the soil, but less accurate than the SWE measured from the K and TI information independently. When the SWE calculated from the K/TI ratio is reached, it is assumed that there is a snow cover. The nominal humidity parameter is then used for the calculation. Otherwise, the snow cover is assumed to be zero, and the GMON3 calculates the humidity of the soil. The default value is 5 mm.

**[17] Baud rate for scheduled transmissions**

This parameter defines the baud rate to be used for the automatic data transmissions. In interactive mode with a terminal, the GMON3 can adjust to the terminal’s baud rate by typing capital U period then Enter “U.<Enter>”. However, for scheduled transmissions, the GMON3 will use the baud rate specified by this parameter. This is for the cases when an interactive terminal used for the configuration of a site is disconnected and replaced by the normal communication device (modem, satellite, datalogger) with a different baud rate. This guarantees that the scheduled transmissions will be done at the proper baud rate for the communication device. The default rate is 9600BAUD. Valid values

for this parameter are: 1200, 2400, 4800, 9600, 19200, 38400, 57600, and 115200.

**[18] Number of hours per partial histo (hours),(1,2,3,or 6)**

It is highly recommended to leave this setting to 1 hour. It is recommended to contact Campbell Scientific technical support prior to using other values.

In normal operation 1 Hour histograms generate, 24 partial histograms per day. However, under very large snow packs (more than 500mm.), the absorption of the gamma rays is such that the peaks do not stand up much above the cosmic radiation background after one hour of counting. In this case, the peak identifying mechanism may fail. To overcome this situation, it is possible to have histograms generated in periods of 2,3 or 6 hours.

**[19] Manual mode (1); Auto mode (0) ; HCalib mode (2);**

This parameter defines the operating mode of the GMON3. In the manual mode (code =1), the GMON3 will accumulate a histogram from the initialization cycle until it a manual command is sent to delete it. No calculations of SWE will be performed, and no results transmission will be scheduled. This mode is used normally when setting up the GMON3 (i.e. verifying the peak positions, modifying parameters, setting the time, etc.).

The HCalib mode (code = 2) has been referred to in the parameter description for [10] HCalib. When this mode is set, the GMON3 will acquire the data in a normal manner, and the results will be transmitted at the end of the period at the scheduled transmission time. However, instead of calculating the SWE, it will assume that the SWE is zero. Then, it will perform the inverse SWE calculation, and infer the values of the n0Ke and n0Tl from the measured integrals for the K and Tl isotope peaks, taking into account the humidity of the soil specified in the parameter HCalib. When this is done, the new values of n0Ke and n0Tl will be stored in the parameter block, and the operation mode will be changed internally by the GMON to automatic (code = 0).

The automatic mode (code =0) is the normal mode of operation. The GMON3 will continuously cycle through 24-hour periods, calculating the SWE for the previous 24 hours at 6 hours intervals.

**16. [.S]**

The [.S] command is used to Display status and current measurement information:

System status:

-Present time	: 22/09/2009 15:34:30
-Firmware Version	: 104
-Software Version	: 13m
-Data acquisition start time	: 22/09/2009 15:00:00
-Data acquisition stop time	: 22/09/2009 15:59:50
-Next Results Xmission time	: 22/09/2009 18:05:00
-Elapsed time,current histo	: 00:07:25
-MapIndex	: 4
-CurrentWorkBuffer	: 0
-Cycle	: 16
-ModeTurbo	: 0



-TMax : 24 0 24 0  
 -Min : 24 0 24 0

#### 17. [.0xw]

The [.0xw] command is used to upload new firmware into the GMON3. The “0” character is the number zero. Please refer to the “Firmware Update” section for more details.

#### 18. [.Rsoft]

The [.Rsoft] command is used to Restart the GMON3 software.

#### 19. [%Rhard]

The [%Rhard] command is used to perform a hardware reset of the GMON3.

#### 20. [%Rboot]

The [%Rboot] command is used to perform a reboot.

#### 21. [.Edata]

The [.Edata] command is used to erase all internal data memory. Do not use this command unless you are very sure that the data is no longer required in the GMON3. Once executed, this command cannot be reversed and **ALL DATA IS LOST**.

## 6.5 Datalogger Talk Through Mode

Users who use Campbell Scientific dataloggers such as the CR800, CR1000 or the CR3000 can communicate to the GMON3 directly using the serial talk through mode feature in Loggernet’s Terminal Emulator Mode.

This will allow users to access the GMON3 remotely via the datalogger. This will allow users to do tasks remotely such as change settings or update the GMON3 clock.

## 7. Parts Overview

The following diagram shows a standard GMON3 and some of its included accessories.

The collimator is shipped in a box separate from the GMON3 due to its weight. You will also find a carrying strap for the collimator to facilitate carrying the part.

### CAUTION

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The collimator weighs 55 lbs.

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A long safety strap is also included for securing the collimator to the mounting structure once it is installed.

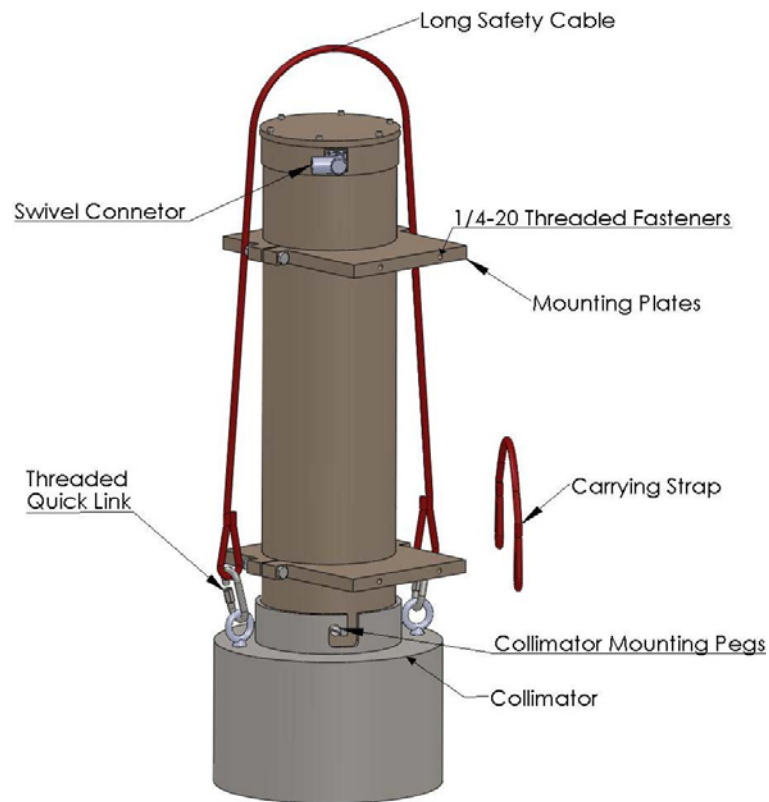


Figure 2. GMON3 Components

## 8. Site Selection Details

Do not mount the GMON3 in close proximity to wood material or trees. Wood material can contain potassium which can be a source of gamma radiation that will interfere with the measurements. Potassium sources above the snow will emit gamma radiation that is not attenuated by the snow pack. A minimum clearance radius of 6 m (20 ft) is recommended from large trees and vegetation that are above the snow pack.

It is reasonable to have small amounts of wood material within the 6 metre clearance radius. Be aware that the reducing the amount of material near the GMON3 or increasing the distance will reduce its influence on the readings.

### 8.1 Soil Moisture Considerations

Moisture in the soil can influence the GMON3 readings. It is important to avoid low lying spots where water will pool or saturate the soil during the snow melt. Sandy or rocky soil types will have more stable soil moisture levels throughout the measurement season. Bog type ground conditions should be avoided due to the potentially high moisture content and variations.

### 8.2 Obtaining Site Qualifying Counts

There is variability in the natural occurring radiation levels from site to site. For this reason it is recommended to qualify the site prior to setting up the permanent installation for the GMON3. You may find that your site has low background levels of K and Tl counts, and moving the location may be required to improve the results from the GMON3.

## Required Equipment:

- GMON3 with accessories
- Suitable +12V DC power supply or battery to run the GMON3 for several hours.
- Suitable mounting mechanism to suspend the GMON3 vertically over the ground at the qualifying site (with the collimator). For qualifying purposes the distance above the ground is not critical.
- Laptop computer with Hyperterminal or another suitable terminal emulator program.

## Steps to follow:

- Mount the GMON3 as close as reasonable to its desired permanent location.
- Avoid placing items underneath the GMON3 during this testing.
- For best results try to maintain a mounting height of 1 metre or more.
- Ensure that the collimator is installed on the GMON3.
- Connect the GMON3 to the Laptop computer and power supply as shown in the wiring section of this manual.
- Run Hyperterminal or the terminal program that you have chosen to use.
- Access the Parameter Setup Menu by typing “.P<Enter>”.
- If not already done, change the operating state of the GMON3 to Manual mode. To do this type “19<space>1<Enter>”.

**NOTE**


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Once the site is qualified the GMON will need to have the operating mode reconfigured to Auto or HCalib mode. This can be done as part of the final parameter setup discussed in Section 10.

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- The GMON3 will automatically save this change and exit the Parameter setup menu.
- Enter into the “Special Command” by typing “.a<Enter>”
- The command will send out a prompt as follows:

Delay and Duration for the measurement (seconds):

- A delay will need to be typed in followed by the run time duration. It is recommended to run the test for 1 or 2 hours a value of 1 second can be entered for the delay. A 1 hour test is 3600 seconds so the following would be type in “1<space>3600<Enter>”.
- The GMON3 will now monitor the gamma radiation for an hour.
- The .hr command can be issued several minutes into the test for verification that it is running properly. The .hr command may take several minutes to complete. Upon completion the command will output the current histogram

(which can be captured to file for advanced diagnostics) followed by the following lines.

-Elapsed time,current histo : 00:03:59

Pos K = 240.4; Pos Tl = 427.5;

Cnt K = 003679.8; Cnt Tl = 000088.3;

The first line indicates how long the GMON3 has been monitoring. The second line indicates the position of the Potassium peak and its counts. The third line indicates the position of the Tl peak and its counts.

It is important to record these numbers and refer to the Radiation Count Range Tables 1 and 2 for determining the suitability of your site.

Table 1. Potassium (K) Count Range Guideline		
Count Range 24 Hour K	Count Range 1 Hour K	Recommendation
0 to 96000	0 to 4000	Insufficient K counts for GMON3 SWE measurements.
96000 to 180000	4000 to 7500	Useable K count range for GMON3 SWE measurements. May experience larger errors for higher SWE values.
180000 to 264000	7500 to 11000	Good K count range for GMON3 SWE measurements. Should maintain specified operating characteristics.
264000 or greater	11000 or greater	Excellent K count range for the GMON3 SWE measurements.

Table 2. Thallium (Tl) Count Range Guideline		
Count Range 24 Hour Tl	Count Range 1 Hour Tl	Recommendation
0 to 9600	0 to 400	Insufficient Tl counts for GMON3 SWE measurements.
9600 to 36000	400 to 1500	Useable Tl count range for GMON3 SWE measurements. May experience larger errors for higher SWE values.
36000 to 48000	1500 to 2000	Good Tl count range for GMON3 SWE measurements. Should maintain specified operating characteristics.
48000 or greater	2000 or greater	Excellent Tl count range for the GMON3 SWE measurements.

## 9. Mounting

### CAUTION

- If you are unable to determine that your structure or mounting method is suitable for the GMON3 sensor, please contact an expert or professional who can assist you in determining the structural mounting requirements for your GMON3 installation.
- Always ensure that the collimator is secured to the structure with the long safety cable.
- Always install the collimator after the main GMON3 body is mounted and secured to the structure.

The exact mounting height for the GMON3 is not critical. However it is recommended to mount the GMON3 approximately 3.0 m (10 ft) above the ground. If it is possible for snow levels to exceed 3.0 m (10 ft), then the GMON3 should be mounted higher than the maximum snow height. If the GMON3 is submersed in the snow, it may be damaged by water ingress. The GMON3 can also be mounted lower than 3.0 m (10 ft); however, this will reduce the effective area of coverage.

Once the GMON3 is mounted the actual installed height will need to be entered into the appropriate setup parameter.

### 9.1 Mounting Options

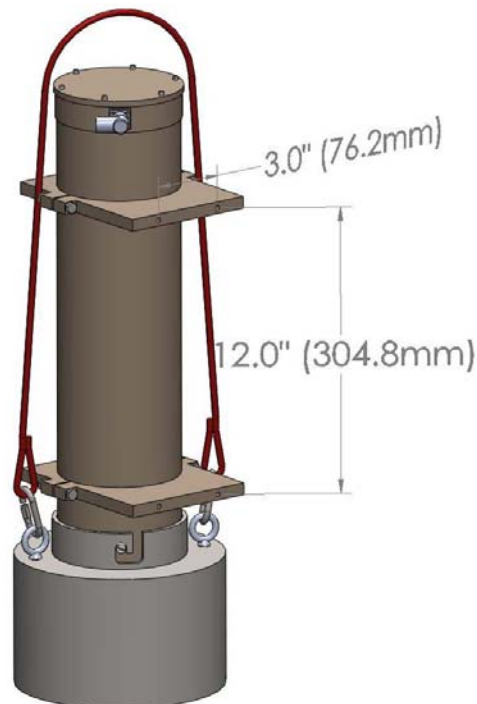
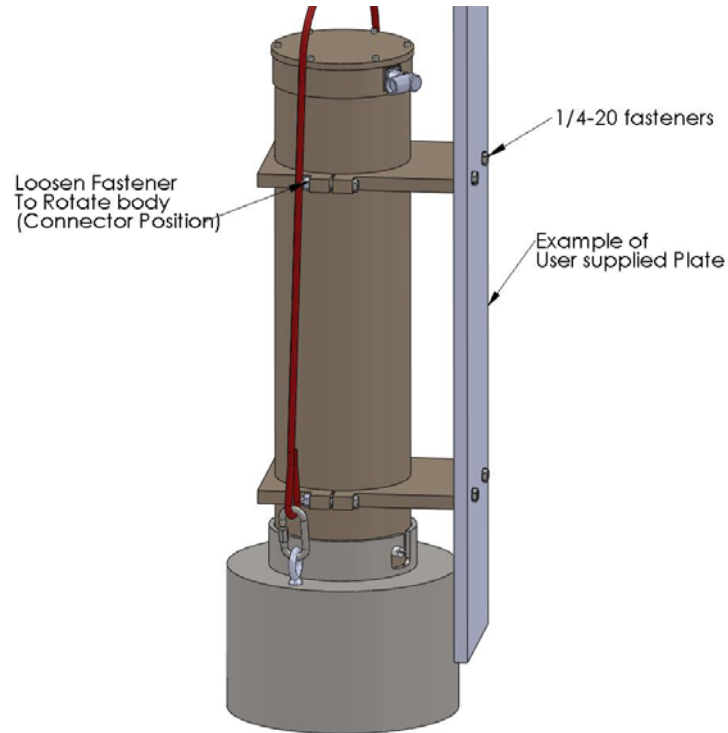


Figure 3. Position of 1/4 - 20 Mounting Holes

The GMON3 comes with mounting plates that can be used with the #27412 mounting kit and #27413 right-angle mounting kit to mount the sensor. The mounting plates contain four 1/4-20 threaded holes for fastening the sensor to the #27413 or wall mount. Refer to Figure 3: Position of 1/4-20 Mounting Holes for details.



*Figure 4. Example of Wall/Plate Mounting*

It is possible to rotate the GMON3's Main Body with respect to the mounting plates. Figure 4: Example of Wall/Plate Mounting shows one of four fasteners that need to be loosened to rotate the main body. Ensure that the fasteners are not loosened too much to prevent the body from sliding through the mounting plates.

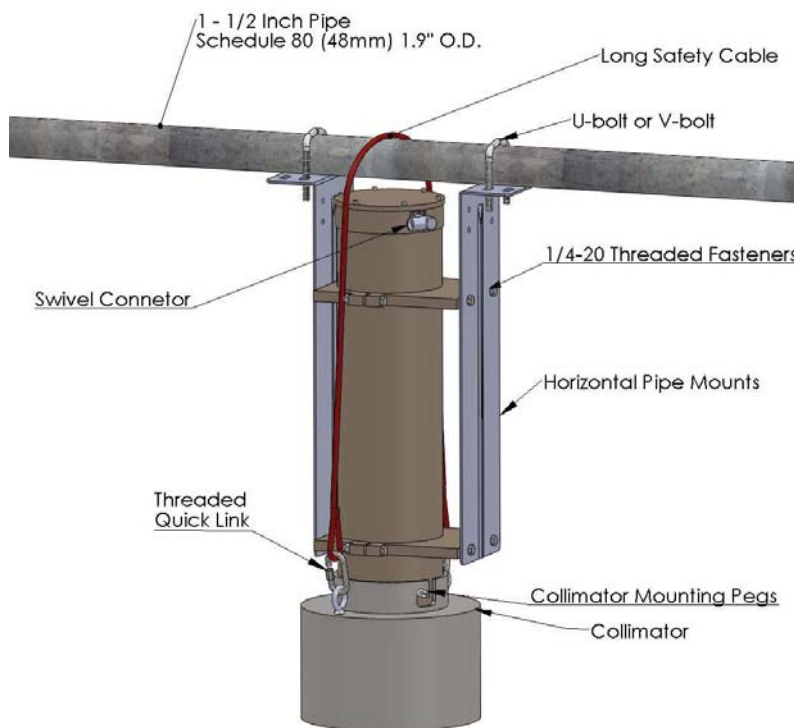


Figure 5. Horizontal Pipe Mounting Shown with the #27412 Mount Kit

A fully mounted GMON3 with the #27412 mounting brackets is shown in Figure 5: Horizontal Pipe Mounting.

## 10. Final Parameter Setup

Once the GMON3 is installed the following items are required for the final setup of the GMON3.

- Obtain the soil moisture values for the ground under the GMON3. The recommended depth of the measurements for most soil types is 20 cm (8 in). However, when well drained soils are present the measurements should be made at a depth of 30cm. The value should be in percent by weight [100 \*(mass of water/mass of dry soil)].
- Measure the final Installed height of the GMON3 in centimetres from the bottom of the sensor to the ground.

It is best to have the GMON3 installed prior to having any snow on the ground. If the GMON3 is being installed with snow already on the ground, then the average existing SWE value in mm will need to be obtained. The existing SWE is needed to calculate the background radiation count with no snow present (i.e. n0Ke and n0Tl parameters). Campbell Scientific technical support will need to be contacted so that calculations can be performed to determine the n0K and n0Tl values.

If the installation is being done with no snow present then the following needs to be done to complete the setup:

Access the Parameter Menu of the GMON3 via the terminal emulator by keying in the command [.P<Enter>]

[1] Station ID	: 001
[2] GMON3's serial number	: 1000
[3] Time of start of measure (relative to GMON3 00h RTC)	: 00
[4] Delay after start of measure for data Xmission (secs.)	: 0
[5] XMitO6h flag: 0 => every 24 h 1 => every 6 h	: 1
[6] GMON3 height above ground in centimetres	: 300
[7] Observed position for the K line on the histogram	: 245
[8] Collim (1: Collimator installed; 0: no collimator)	: 1
[9] Nominal soil moisture in %	: 25
[10] HCalib; Measured soil moisture for auto calibration (%)	: 27
[11] n0Ke	: 223196
[12] n00Ke (residual Ke counting)	: 225
[13] n0Tl	: 32232
[14] n00Tl (residual Tl counting)	: 1900
[15] PcPn in part par thousand	: 50
[16] SN Threshold for the snow cover	: 5
[17] Baud rate for scheduled transmissions	: 9600
[18] Number of hours per partial histo (hours),(1,2,3,or 6)	: 1
[19] Manual mode (1); Auto mode (0) ; HCalib mode (2);	: 0
[.] Quit menu	
[99] Save parameters on EPROM	

- Set parameter [6] to reflect the actual installed height of the GMON3 in cm
- Set parameter [9] to the obtained soil moisture value in %
- Set parameter [10] to the obtained soil moisture value in %
- Ensure any other parameter is set to meet your requirements.
- Set parameter [19] last. Set the value to 2 - "Calibration Mode". When parameter 19 is set to 2 the parameters will automatically be saved. The GMON3 will exit the Parameter Setup Menu and perform a software restart.
- The setting can be verified by going back into the [.] Parameter Menu again.

By placing the GMON3 in Calibration Mode (HCalib) it will automatically adjust the initial n0Ke and the n0Tl values for you. The n0Ke and the n0Tl values can also be calculated by running the GMON3 for 24 hours and observing the radiation count values seen in the detailed measurement data output string which can be accessed by typing the command [.]FI].



## 11. Firmware Update (using command .0xw)

The firmware for the GMON3 can be updated using the RS-232 serial communication interface. This can be accomplished by connecting the GMON3 to a computer using the DB9F-TERM (see the section “Connecting the GMON3 to a computer”).

A terminal communication program such as Hyperterminal will be required to transfer the new firmware file to the GMON3.

The firmware update involves the transfer of a large file and for this reason the BAUD rate setting can be increased for the program update procedure. The maximum BAUD rate that can be used is a function of the cable length. The following table shows the recommended maximum BAUD rate for various cable lengths:

Cable Length	Maximum BAUD Rate
0 to 7.6 m (0 to 25 ft)	57600
0 to 15.2 m (25 to 50 ft)	38400
0 to 30.5 m (50 to 100 ft)	9600

Terminal settings should be as follows:

BAUD Rate:	See Table above
Data Bits:	8
Parity:	None
Stop Bits:	1
Flow Control:	XON/XOFF
Local Echo:	Enabled
Terminal Mode:	ANSI
Send Line Ends with Line Feeds:	Disabled

Note that the XON/XOFF flow control needs to be enabled. For all other normal communications the XON/XOFF flow control will need to be disabled.

Once the Terminal program is setup and the GMON3 is connected to the computer using the DB9F-Term, power can be applied to the GMON3.

If a BAUD rate other than 9600 was selected the Auto BAUD rate synchronization can be invoked by typing the command “U.<Enter>”. Once the menu is displayed the command “.0xw” can be entered for reprogramming the firmware.

The following will be displayed once the “.0xw” is entered:

*allocating memory buffer,,,,,,,,,,*

After the memory is allocated (within 1 minute) the GMON3 will prompt for the file transfer with the following message:

***Launch the file transfer with the Hyper Terminal***

If you are using HyperTerminal, select “Send Text File...” from the Transfer menu.

The supplied programming file will need to be selected and sent to the GMON3. The process will take approximately 5 minutes at 57600 BAUD and in excess of 30 minutes at 9600 BAUD. If the scrolling characters stop for a long duration it is possible that an error occurred in communications. Shut down Hyperterminal, power down the GMON3 and restart the process again.

A single line of scrolling data will be displayed as the transfer takes place. Once the transfer is complete the following text will be displayed on the Terminal:

*Transfer completed; type w to overwrite the EPROM memory, type . to abort*

**CAUTION**

---

Once the following step is done it is critical to not interrupt this process or power down the GMON3. If the process is interrupted, the GMON3 may need to be sent back to the factory for reprogramming.

---

Type in the character w followed by the Enter Key “w<Enter>”.

After the w command is entered, the terminal will display that the programming has begun and the progress will be displayed as follows:

*Begin EPROM programming*

*Erasing block 0x0*

*Writing EPROM from 0x0 to 0xffff*

Upon completion the GMON3 will prompt to be reset. It is recommended to cycle power only after the following message is displayed:

*Programming done .. cycle power on the GMON, or do a Hard Reset*

It is recommended to restart Hyperterminal as well and change the BAUD rate setting back to 9600 BAUD and to disable the XON/XOFF flow control to resume normal communications and verify that the GMON powers up properly and retained its Parameter settings.

## 12. System Power Requirements and Recommendations

### 12.1 Non Solar Powered Sites

It is always recommended that the GMON3 be operated from an uninterruptable power supply. Normally an AC charger is used to charge +12 volt batteries. For sites that operate this way it is recommended that the batteries have the capacity to supply the system for a minimum of 48 hours. This should be increased for sites where frequent power outages are possible.

### 12.2 Solar Powered Sites

The maximum power draw from the GMON3 is 180 mA or 4.32 Amp-Hours per day. It is recommended that solar powered systems be designed with a minimum reserve capacity of 60 days. This results in a minimum reserve capacity of 260 Amp-Hours for the GMON3. It is also important to account for the power draw from other equipment that may operate from the power supply.

The following are some reasons for the large reserve capacity.

- Solar panels can become covered in ice and snow and charging may not be present for long periods of time.
- Battery capacity decreases with cold temperatures.
- Cold temperatures also significantly reduce a battery's capacity to charge. Generally very little charging occurs at temperatures below -30°C.

#### Solar Panel Size

The size of solar panel required for charging the GMON3 system should be sized according to the geographic location of the installation and total maximum system power draw.

## 13. Detailed Measurement Theory

The GMON3 sensor is in fact a Gamma Radiation Spectrometer that has been specifically designed for the purpose of measuring SWE. The GMON3 utilizes a Thallium doped Sodium Iodide crystal NaI(Tl) for detecting the gamma radiation.

The natural gamma radiation from the ground is produced by the traces of long lived radioactive elements that it contains. The most abundant of those elements is Potassium\_40 (40K) and Thallium\_208 (208Tl). Potassium\_40 emits gammas at 1.460 MeV (megaelectronvolts), and Thallium\_208 at 2.613 MeV. Gamma rays have a well defined "probability of interaction" per unit of length as they go through a material according to the energy of the gamma and the nature of the material. The net effect when the natural gamma rays from the ground go through the snow cover is that a fraction of the gammas do not interact at all with the snow, and that another fraction is either degraded in energy, or totally absorbed in the snow. The precise measurement of the absorption and energy degradation by the snow of the gamma rays from the ground is the basic information for the calculation of the SWE.

Each time a gamma ray is detected by the GMON3, it is placed in its corresponding bin in the energy histogram. This histogram is the basic data set for the calculation of the SWEs. Since it is statistical in nature, the accuracy of the SWE evaluation is proportional to the square root of the measurement time. The

GMON3 builds each histogram for a period of 24 hours in order to achieve the specified accuracy. An example of such a histogram is shown in Figure 6: Gamma Histogram.

It should be noted that only selected portions of the histogram can be used to evaluate the SWE. The reason is that the SWE is evaluated by measuring the absorption by the snow cover of the natural radiation coming from the ground. However, some of the measured radiation comes from above the snow cover. This is the case of the cosmic radiation and the bismuth isotopes produced by the radon decay chain. In short, the integrated counts under the  $^{40}\text{K}$  and  $^{208}\text{Tl}$  peaks need to be evaluated after removing or accounting for all the other contaminants.

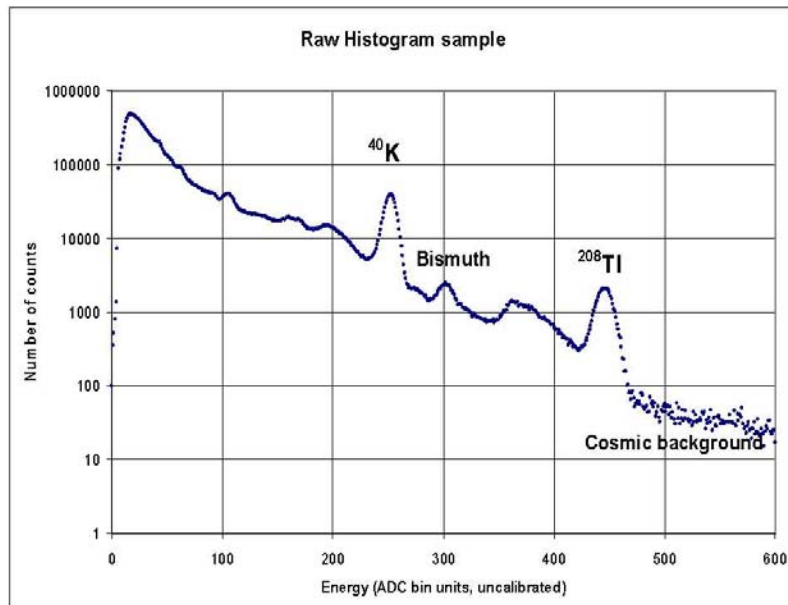


Figure 6. Gamma Histogram

## 14. Maintenance and Assembly

There is no recommended user maintenance required for the GMON3.

### CAUTION

We do not recommend disassembling the GMON3 for any reason. The GMON3 instrument is a very complex and is intended to be repaired or maintained only by factory trained personnel.

It is recommended that the GMON3 be calibrated every 7 years. The reason for the timeline is to ensure the GMON3 gamma ray detector does not drift out of specification.

The following diagrams demonstrate the internal makeup of the GMON3. To reduce drastic temperature gradients the GMON3 is filled with an advanced insulating material known as Nanogel (See Figure 9: GMON3 Cutout). The manufacturer's (Cabot Corporation) MSDS sheet should be consulted to prior to exposing the Nanogel insulation.



Figure 7. GMON3 Main Body

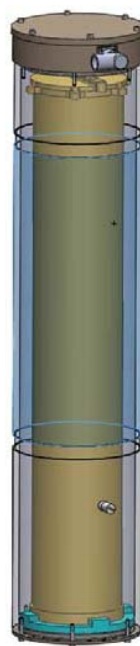


Figure 8. GMON3 Inner Tube Shown

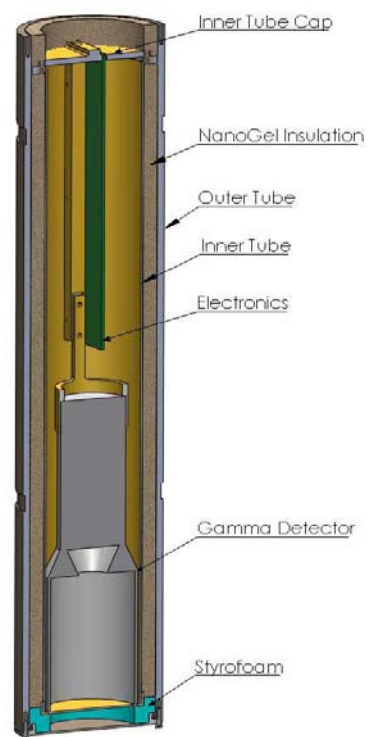


Figure 9. GMON3 Cutout View

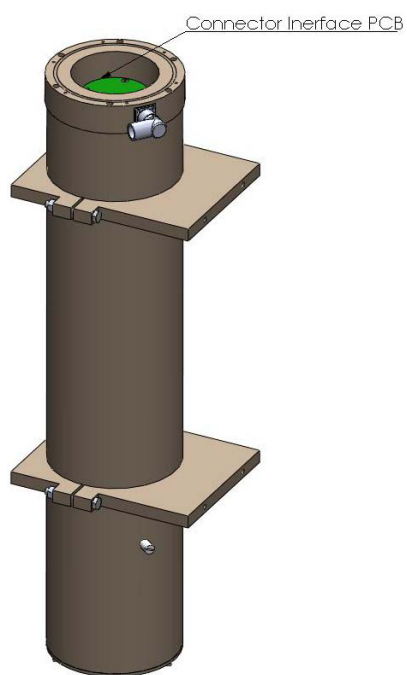


Figure 10. GMON3 with Top Cap Removed

## 15. Datalogger CRBasic Programming

The following program example reads the SWE values from the GMON3 using the command [.Fs].

The format of the data output from [.Fs] command is as follows:

```
DD/MM/YYYY HH:MM:SS SWE_K SWE_TL
01/10/2009 06:59:50 123 129
```

```
'CR1000 Series Datalogger
'Program for GMON3 Sensor

'Wiring GMON3

'Red -Power          +12VDC
'Black -Power Gnd    G - Ground
'Green -RS-232 TX    C2
'White -RS-232 RX    C1
'Clear -Shield       G - Ground

'Declare Public Variables
Public PTemp As Float,batt_volt As Float
Public Read_GMON3_SWE_Flag As Boolean
Public GMON3_RET_Values(8) As Float

Public GMON3SerialIn As String * 100
Public GMON3_COMMAND_String As String * 20

Alias GMON3_RET_Values(7) = SWE_K
Alias GMON3_RET_Values(8) = SWE_TL

'Declare Constants

'Command to Read back last results in short data output form
'precede .Fs with an ESCAPE key CHR(27) and end with an Enter CHR(13)
Const GMON3_Command_get_output = CHR(27) + ".Fs" + CHR(13)

'Define Data Tables
DataTable (Diagnostics,1,-1)
    DataInterval (0,1440,Min,10)
    Minimum (1,batt_volt,FP2,0,False)
    Maximum (1,batt_volt,FP2,0,False)
    Minimum (1,PTemp,FP2,0,False)
    Maximum (1,PTemp,FP2,0,False)
EndTable

'Define Data Tables
DataTable (GMON3Hourly,1,-1)
    DataInterval (0,60,Min,10)
    Sample (8,GMON3_RET_Values(1),IEEE4)
EndTable

'Main Program
BeginProg

    'Prepare COM1 for the GMON3
    SerialOpen (Com1,9600,3,0,10000)

    'Scan rate is dependent on application
```

```

Scan (30,Sec,7,0)
  PanelTemp (PTemp,250)
  Battery (batt_volt)

'Based on the Factory default settings of the GMON3 the GMON3 will
'calculate SWE on the Hour every 6 Hours.
'We will simply read the GMON3 every hour in this program.
'The reading will take place 10 minutes After the hour to ensure the GMON3
'is not burdened with extra processing when the measurement is requested

If TimeIntoInterval (10,60,Min) Then Read_GMON3_SWE_Flag = TRUE
EndIf

If Read_GMON3_SWE_Flag = TRUE Then
  'Reset the Flag
  Read_GMON3_SWE_Flag = False

  'Load the command into the string
  GMON3_COMMAND_String = GMON3_Command_get_output

  'Send the command string out
  SerialOut (Com1,GMON3_COMMAND_String,"",0,0)

  'Wait up to 2 seconds, a <CR> or 100 chars for the values to be returned.
  SerialIn (GMON3SerialIn, Com1, 200,13, 100)

  'The string is in the following format
  '23/09/2009 18:59:50 123 456
  'Split out the time stamp and values 8 numbers are returned
  SplitStr (GMON3_RET_Values(),GMON3SerialIn,"",8,0)
  'The contents of the array are as follows:
  'Day,Month,Year,Hour,Min,Second,SWE-from K, SWE-from TL
EndIf

'Call Output Tables.
CallTable Diagnostics
CallTable GMON3Hourly

NextScan

EndProg

```





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