FIELDSCOUT®

CM 1000
NDVI Meter

PRODUCT MANUAL

Item # 2953

Spectrum®

Contents

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General Overview

The **FIELDSCOUT® CM1000** NDVI (Normalized Difference Vegetation Index) Meter senses light at wavelengths of 660 nm and 840 nm to estimate plant health. The ambient and reflected light at each wavelength is measured. Chlorophyll absorbs 660 nm light and, as a result, the reflection of that wavelength from the leaf is reduced compared to the reflected 840 nm light. Light having a wavelength of 840 nm is unaffected by leaf chlorophyll content and serves as an indication of how much light is reflected due to leaf physical characteristics such as the presence of a waxy or hairy leaf surface.

♦ Lasers define the target as the trigger is pressed. At a distance of 11.2 inches (28.4 cm), the field of view is 0.434 inches (1.10 cm) in diameter. At a distance of 72 inches (183 cm), the field of view increases to 7.4 inches (18.8 cm) in diameter.

♦ A NDVI value (-1 to 1) is calculated from the measured ambient and reflected light data. [(%Near Infrared-%Red) / (%Near Infrared + % Red)]

♦ The number of samples taken and a running average of NDVI values is displayed.

♦ Ambient light level is displayed on a scale of 0 to 9.

♦ The optional data-logging system records the latitude and longitude (if GPS is used), the sample number, the individual NDVI reading, and the value assigned to the ambient light level.

♦ The recorded data is downloaded to your PC using the optional FieldScout® software.

♦ The data-logged files are comma-delimited text files and can be opened and worked with in any spreadsheet, graphing, statistical, or word processing

Initial Startup

Allow the temperature of the CM1000 NDVI meter to equilibrate with the plant environment prior to sampling. For example, storing the meter overnight in a freezing tool shed and then immediately taking readings upon entry into a warm greenhouse will result in invalid data.

When the CM1000 NDVI meter is first turned on, battery strength (**Battery at __%**) will appear on the LCD. The available battery power percentage assumes alkaline batteries are being used. If rechargeable NiCd batteries are installed, the available battery power will be less than displayed. If the data logging option has not been enabled, the unit will then proceed to the normal reading mode.

In order to record data and global positioning system (GPS) coordinates, the data logger must first be enabled through the software (See p. 13). If the data logger has been enabled, battery strength and the amount of remaining memory (**Memory __ % FULL**) will be displayed. If GPS data is being recorded as well, the meter will display the status of the GPS signal. The meter will then proceed to the normal reading mode.

IMPORTANT: The **GPS** unit must be powered up, have located the satellites and been connected to the meter before turning the meter on (see Connecting to GPS Unit p. 5).

Connecting to a GPS Unit

The optional data logger function must be enabled using the Field Scout software in order to record a GPS signal (see Meter Settings p. 13).

The GPS unit must be plugged into the CM1000 NDVI meter and working when the meter is first turned on. If a GPS signal is found at startup, the logger will search for a GPS signal for every reading. If no GPS signal is found when the meter is first turned on, the meter will not search for one when taking readings, thereby saving time when taking readings. In this case the LCD will display the **No GPS Found** message.

For each reading, **GPS** will be displayed on the bottom right of the screen. If the GPS signal is lost during a series of readings, or if the specified differential correction is lost, the LCD will display **LOG** rather than **GPS** in the lower right corner of the screen. During subsequent readings, the meter will again search for a GPS signal and upon finding one, will again display **GPS**.

GPS Setting
Your GPS unit must be set for NMEA 0183 input/output messages. If the meter has trouble receiving the GPS signal, check that the GPS unit has the following settings:

Data bits: 8	Stop bits: 1
Baud rate: 4800 bps	Parity: None
Timing: 1 second	GGA data string

Cable Connections

A GPS/DGPS cable (item # 2950CV5) is required to connect the CM 1000 NDVI meter to a GPS unit. This cable has a 9-pin male connection and a stereo pin that connects to the meter's data port. You will also need a cable that allows the GPS unit to connect to a 9-pin male serial port. If this cable doesn't come standard with your GPS unit, it should be available from the manufacturer. This cable is generally used to upload information from a computer to the GPS unit. These components should be connected as shown in the figure below.

Spectrum GPS/DGPS Cable

GPS computer interface cable
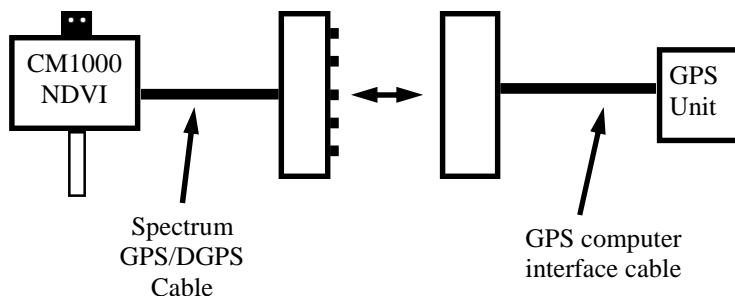
Connecting the CM1000 NDVI meter to a GPS unit

Keypad Operation
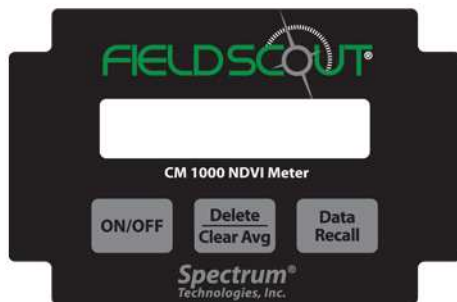
The ON/OFF button turns the meter on and off. When the meter is turned on, it will display the battery status for 3 seconds. The screen will then display the amount of memory available and the status of the GPS connection. The meter then goes into normal reading mode.

CAUTION: If the meter is inactive for 20 minutes, it will automatically turn off to conserve power. When the meter is powered off, either with the ON/OFF button or due to inactivity, the AVG and N values are reset to zero (see Normal Reading Mode, p. 9)

```
BATTERY AT 85%
      V5.0
```
Battery status screen

```
LOGGER 28% FULL
  NO GPS FOUND
```

```
LOGGER 35% FULL
GPS=YES DGPS=YES
```
Logger and GPS status screens

```
NDVI=.71 BRT=4
AVG=.75 N015 LOG
```
Data screen

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Data Recall

As NDVI measurements are taken, up to 99 readings are stored in the meter's short-term memory. These will be the readings taken since meter was turned on or the **Delete/Clear Avg** button was pressed This is separate from the internal data logger. The readings in short-term memory can be reviewed by hitting the **Data Recall** button. With each press of the button, the LCD will display the preceding data point (**INDEX** and **BRT** values). The next time the trigger is pressed, the LCD will revert to normal reading mode and the current **N**-value will be displayed along with an updated Average.

Delete Clear Avg

When the DELETE/CLR AVG button is pressed and immediately released, the last data point will be removed from the short-term memory and the running average. Pressing and holding this button will reset the running average (**AVG**) and **N**-value to zero.

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Normal Reading Mode

Taking Readings

When the meter is on, pressing the trigger on the front of the handle will activate the targeting lasers and will cause the measuring and calculating mechanism to become "Live". That is, while pulling the trigger, the user can see the NDVI value (see below) being constantly updated as the targeting lasers are moved around the leaf surface. Releasing the trigger locks in the **NDVI** reading and incorporates that reading into the running average and the logger's memory.

NOTE: Readings should be taken only on individual leaves. Canopy-level measurements are encouraged only for fine-textured turf grass. (See Light Management, p. 17)

When in normal reading mode, the LCD of the CM1000 NDVI meter will display the NDVI value, the brightness reading from the ambient light sensor, a running average and indicate whether the data logger is functioning. The contents of the LCD are explained below.

NDVI

The CM 1000 NDVI reading is reported on a scale of –1 to 1. The **NDVI** value is a measure of the relative greenness of the leaf. It is calculated as [(%Near Infrared -%Red) / (%Near Infrared + % Red)]. This value remains in the meter's short-term memory until it is deleted or the meter is shut off (see Keypad Operation, p. 7). If the data logger is enabled the **NDVI** value is also recorded in the logger's memory.

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BRT

The response of the ambient light sensor is displayed as a brightness index value (**BRT**) from 0 - 9. A **BRT** value of one or greater indicates that there are at least 250 to 300 $\mu mol \cdot m^{-2} \cdot s^{-1}$ of PAR (photosynthetically active radiation) light available. This is the minimum light level at which the meter is useful. At low levels of ambient light, the index reading may be suspect Full sun should return a **BRT** value of seven to eight. Because of the way the CM1000 NDVI meter estimates chlorophyll content, higher light levels enable greater resolution in the NDVI. (Also see Light Management, p. 17)

NOTE: Excessively bright ambient or reflected light will saturate the light sensors and thereby cause invalid readings. When the light sensors near the saturation point, an LCD message of **ERROR**, **EXCESSIVE LIGHT** will appear.

AVG and N

As each reading is taken, i.e. each time the trigger is released, the **NDVI** reading is incorporated into the running average (**AVG**) and the sample number (**N**) is incremented. The current **AVG** and **N** are both displayed on the bottom line of the LCD.

Although **N** can increment up to 250, only a maximum of 64 **NDVI** readings (**N064**) can be used to generate the running **AVG**. If more than 64 readings are taken before the short-term memory is cleared, the screen will display **AVG=- - -**. However, deleting an **NDVI** reading from short-term memory (thus causing a new **AVG** to be calculated) does not free up memory space for storing an additional reading. In other words, the average is not calculated if the trigger has been pressed more than 64 times without clearing the average (see Keypad Operation, p. 7).

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Valid **NDVI** readings can be taken beyond the maximum **N** value of 250. But **N** will not continue to increment unless the entire current data series is cleared, resetting **N** to zero.

LOG

The data logger must be enabled in order to download data to a PC (See Meter Settings, p. 13). The **LOG** symbol will be displayed in the lower right corner when this feature is enabled.

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Connecting to a Computer

The data port on the underside of the CM 1000 NDVI meter can be accessed by removing the plastic screw. It is through this port that the meter is connected to either a PC or to a GPS unit.

Connecting to a PC

The CM1000 NDVI software comes with a black PC interface cable. This cable connects to the USB port of your computer and to the meter's computer port. The meter's configuration can be modified by clicking on the Meter Settings button (see Meter Settings, p. 13). The Com Port, Meter Type, Download, Clear Memory and Meter Settings buttons are explained in the Main Toolbar section (p. 13).

Note: Prior to 2014, the meter was shipped with a gray cable that connected to a 9-pin serial port. This cable will still work but may require a USB-to-serial adapter.

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Field Scout Software

Meter Type

The Field Scout software supports all of Spectrum Technologies' portable data logging meters. Be sure to select the CM 1000 NDVI Meter from the **Select Meter Type** screen
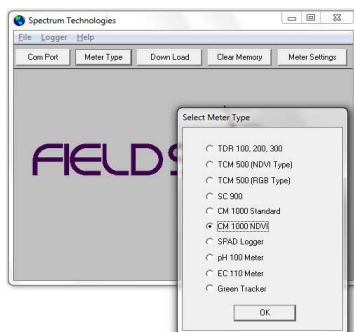
Com Port

The black software cable connects the meter to the computer data port. The port is located at the bottom of the meter. Clicking the **Com Port** button will bring up the **Port Selection** screen. Select the Com Port that is assigned to the computer data port. For most machines, this will be COM 1. See Identifying the Correct Com Port (p. 7) for instructions on how to determine which port to select.

Meter Settings

Clicking on the **Meter Settings** button will bring up the **Meter Settings** screen. This screen allows you to configure the meter. The **Meter Name** will be the title on the first line of the downloaded files.

The logging function is

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enabled by checking the first box in the **Logger Settings** section. If the second box in this section is checked, the logger will store GPS data only if it has been differentially corrected. If the differential correction is not found, only the chlorophyll reading will be stored in the data file.
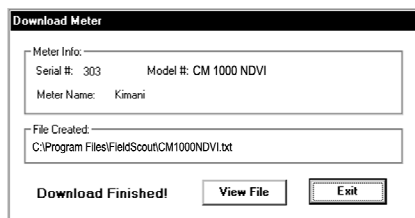
Download

After clicking the **Download** button, a progress bar will confirm that data is being extracted from the logger. When completed, the **Save Data As** box will appear. From here you can give the data file a descriptive name and select a folder in which to save it. The folder selection field on the right allows you to browse to any folder in your system.

When the file has been saved, the software will give you the option of immediately viewing the file. The data file is stored as a comma-delimited text file and may be viewed in any text editor or spreadsheet software.

Clear Memory

Data is not automatically removed from the logger memory after a download. The **Clear Memory** button clears all data from the memory.

Download Meter

Meter Info:
Serial #: 303   Model #: CM 1000 NDVI
Meter Name: Kimani

File Created:
C:\Program Files\FieldScout\CM1000NDVI.txt

Download Finished!   View File   Exit

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Data Files

	A	B	C	D	E	F	G
1	Name: Test						
2	Serial # 55						
3	Datum: WGS 84						
4	Longitude	Latitude	No.	Red %	NIR %	NDVI	
5			Logger Started: 10:19:16				
6	-88.3567	41.31134	N=1	70.5	75.5	0.034	
7	-88.3567	41.31134	N=2	70.9	75.7	0.033	
8	-88.3567	41.31134	N=3	70.9	75.7	0.033	
9			Logger Started: 10:31:39				
10			N=1	12.2	65.4	0.686	
11			N=2	12.4	65.2	0.680	
12			N=3	12.8	65	0.671	
13			N=4	14.6	64.5	0.631	
14			N=5	15.2	64.3	0.618	
15			N=6	15.8	64.1	0.605	
16			Logger Started: 14:22:16				
17	-88.3557	41.31218	N=13	10.5	69.1	0.736	
18	-88.3557	41.31218	N=14	10.7	68.9	0.731	
19	-88.3557	41.31218	N=15	10.9	68.6	0.726	
20	-88.3557	41.31218	N=16	13.3	69.6	0.679	
21	-88.3567	41.31218	N=17	12.8	68.4	0.685	
22	-88.3567	41.31218	N=18	12.6	67.7	0.686	
23	-88.3577	41.31218	N=19	11.8	65.7	0.695	
24	-88.3577	41.31218	N=20	12	65.4	0.690	
25	-88.3577	41.31218	N=21	12.2	65.2	0.685	
26							
27							

Kimani Field.xls — TCM NDVI

Sample data showing results of data collected with and without GPS activated. Note: GPS signal not found when recording data in lines 10 through 15.

The data is stored in comma-delimited text files. These files can be opened with text-editing software (e.g. Microsoft Word) or spreadsheet software (e.g. Excel).

The first two lines of the data file give the logger's name and serial number. The third line indicates that latitude and longitude are referenced to the 1984 World Geodetic Survey datum. The fourth line shows the column headings for the rest of the data file.

Logging sessions are started and completed by turning the meter on and off. The start of a logging session is indicated by the data line "Logger Started." If a GPS signal was found at the start of a logger session, a time stamp is included on the "Logger Started" line.

The data file is separated into 6 fields: Latitude and Longitude (blank if a GPS unit was not connected), sample number, Red reflectance, Near Infrared reflectance, and NDVI.

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Identifying the Correct Com Port

The computer **Com**munications **Port** to which the cable is connected can be identified by using a paper clip.

1. Disconnect the serial cable from the meter.

2. To bring up the **Port Selection** screen, click on the **Com Port** Button, select the com port to be tested and click the **Port Test** button. Click the **Test Port Now** button. If the message "Connection OK" is displayed, another device (such as a modem) is probably connected to that port. If the message "No Connection" is displayed, this port may be the one connected to your serial cable and you can proceed to the next step.

3. Place a paperclip on the end of the serial pin so that it touches both the tip of the pin and the metal area between the two black rings.   Again click on the **Test Port Now** button. If the message "Connection OK" now appears, this is the com port connected to your serial cable.

paper clip
or wire
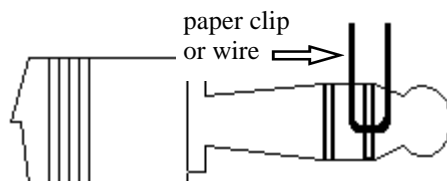
NOTE: The meter does not short-circuit the serial pin. Therefore, when the **Test Port Now** button is clicked while the meter is connected, the "No Connection"

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Light Management

Natural sunlight is the best source of light for measuring plant reflectance because both wavelengths are present in approximately equal quantities and the quantity of light remains relatively constant. With artificial light sources, the user must be aware that different light sources emit light having different qualities. For example, florescent lights emit more blue light and incandescent lights emit more red light. The light sensors in the CM1000 NDVI meter are sensitive enough to detect the cooling of the filament in an incandescent light bulb as the 120 volt AC current alternates from positive to negative and back again at the rate of 60 Hz. The sensitivity of the meter to light quality enables the meter to estimate plant health.
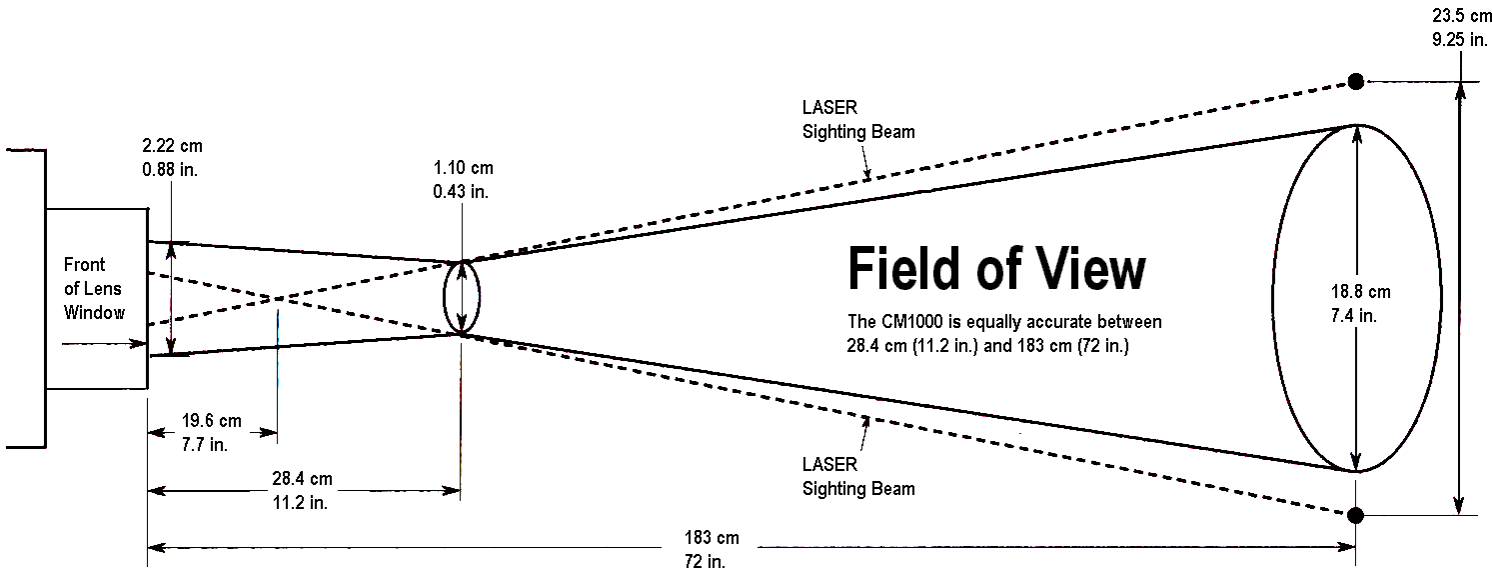
When using artificial light, the CM1000 NDVI meter senses light quantities using a time period that takes into consideration the 60 Hz alternating current used by electric power companies in the U.S. The meter must be reconfigured to be used in Europe and other regions where 50 Hz AC power is used. Compared to light generated with AC current, DC light sources provide a steady light output. In some situations, it may be easier to use a DC light source than to concern oneself with the frequency qualities of AC.

It is important to develop a standard method for taking readings with the CM1000 NDVI meter. Ideally, the sun is always at the user's back and the line between the sample and the sensors is approximately parallel to the sun's rays. The ambient light sensors are behind the white Teflon dots in the black rectangular box on top of the yellow case.   The Teflon dots diffuse the ambient light and protect the ambient light sensors. The user can tilt the black box so that the ambient light sensors are directly facing the sun, thereby enhancing the capture of ambient light.

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Like the ambient light sensors, the target leaf should always be held perpendicular to the sun's rays to maximize light reflectance into the meter's lens from the leaf surface. All samples must be taken against the same background. It is preferable to hold the leaf with one's hand, not having anything immediately behind the leaf. If that is not practical, a flat black background should be used behind the leaf samples. With light-colored or glossy backgrounds, one may not only be sensing the reflective properties of the leaf but also the reflective properties of the background shining through the leaf.

It is preferable to sample with the leaf still attached to the plant. The effect on light absorption or reflection due to the extreme water stress of detached leaves is not known.

Canopy-level measurements are recommended for fine-textured turf grass only . When making measurements on turf grass, an adequate measuring procedure should include having the sun, the target, and the meter in approximately the same relationship with each other for each reading. The problem with trying to measure an entire plant canopy is that not all leaves in a coarse canopy are exposed to the same ambient light. Because the light reflected from a canopy is being reflected in many different directions and that reflected light is being compared to the available ambient light, it is absolutely necessary for the both the entire sample area and the ambient light sensors to be subjected to the same quantity and quality of light.

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23.5 cm
9.25 in.

2.22 cm
0.88 in.

1.10 cm
0.43 in.

LASER
Sighting Beam

Front
of Lens
Window

Field of View

The CM1000 is equally accurate between
28.4 cm (11.2 in.) and 183 cm (72 in.)

18.8 cm
7.4 in.

19.6 cm
7.7 in.

28.4 cm
11.2 in.

LASER
Sighting Beam

183 cm
72 in.

This drawing is not to scale.

Specifications

Measurement Sample	Individual plant leaves turf grass canopy
Measurement System	Reflectance of 660 nm and 840 nm light (10 nm FWHM)
Light Requirements	Natural sun light Artificial light: 60 Hz AC tungsten or halogen powered by DC current *Contact Spectrum for use with 50 Hz AC (Europe)*
Measurement Area	Conical field-of-view between 28.4 and 183 cm
Measurement Units	NDVI (Normalized Difference Vegetation Index) on a scale of –1 to 1
Logger Capacity	3250 readings without GPS/DGPS 1350 readings with GPS/DGPS
Repeatability	± 5% of measurement
Weight	1.5 lbs. (0.7 kg)
Temperature Range	Operate in 32° to 104° F (0° to 40°C)
Power	Two AAA alkaline batteries Approximately 3000 measurements
Environmental Sealing	Dust-proof

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Error Messages

EXCESSIVE LIGHT	This error occurs when any of the four light sensors are saturated due to the ambient or reflected light being too bright.
MEMORY FULL	This error occurs when the optional data logger capacity has been reached. Download the data and clear the memory.
LOW BATTERY	This error message begins to flash when the alkaline battery level reaches 20%. Turn the meter off and replace the batteries.

Frequently Asked Questions

Why doesn't my CM1000 NDVI meter detect my GPS signal?

The GPS receiver must be turned on and receiving satellite signals prior to turning on the CM1000 NDVI meter.

The data output from the GPS must be specifically set for NMEA text. This setting is in the GPS receiver itself, not in the CM1000 NDVI meter or software.

I have new batteries. Why doesn't my initial startup screen read "Battery at 100%"?

The battery strength indicator is set to accurately detect the strength of alkaline batteries. The displayed battery strength of NiCad batteries will be less than 100%.

Does the CM1000 NDVI meter transmit any signal or light to the target?

No. The CM1000 NDVI meter only senses the light being reflected from the target and compares that reflected light to the ambient light available for reflection.

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Warranty

This product is warranted to be free from defects in material or workmanship for one year from the date of purchase. During the warranty period Spectrum will, at its option, either repair or replace products that prove to be defective. This warranty does not cover damage due to improper installation or use, lightning, negligence, accident, or unauthorized modifications, or to incidental or consequential damages beyond the Spectrum product. Before returning a failed unit, you must obtain a Returned Materials Authorization (RMA) from Spectrum. Spectrum is not responsible for any package that is returned without a valid RMA number or for the loss of the package by any shipping company.

DECLARATION OF CONFORMITY

$C\!\in$

Spectrum Technologies, Inc.
3600 Thayer Court
Aurora, IL 60504 USA

Model Numbers: 2953
Description: CM1000 NDVI meter
Type: Electrical Equipment for Measurement, Control, and
                              Laboratory Use

The undersigned hereby declares, on behalf of Spectrum Technologies, Inc. of
Plainfield, Illinois, USA, that the above referenced product, to which this
declaration relates, is in conformity with the provisions of:

Directive: 2004/108/EC
Standards: EN 61326-1:2006
                              EN 61000-4-2:1995, including A1:1998 and A2:2001
                              EN 61000-4-3:2002
                              EN 55011:2007

Douglas L. Kieffer,
Soil/Water Products Manager   February 27, 2009

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