



Data Collection System

User's Manual

Version 2.0

*For Em5 and Em5R data loggers
and Rm1 radio receiver*

Decagon Devices, Inc.

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EM5 User's Manual

Table of Contents

1. Introduction

Welcome

Welcome to the Em5 data collection system. The Em5 is designed to provide you a convenient, high-quality data collection system at a relatively low cost. This manual will explain the Em5's capabilities and functions.

Contact Information

To contact Decagon for customer support or questions:

- **Email** us at **em5@decagon.com**
- Send us a **fax** at: **(509) 332-5158**
- **Call** us at: **1-800-755-2751** (US and Canada only)
or **509-332-2756**.

Warranty Information

The Em5 has a 30-day satisfaction guarantee and a one-year warranty.

Seller's Liability

Seller warrants new equipment of its own manufacture against defective workmanship and materials for a period of one year from date of receipt of equipment (the results of ordinary wear and tear, neglect, misuse, accident and excessive deterioration due to corrosion from any cause are not to be considered a defect); but Seller's liability for

defective parts shall in no event exceed the furnishing of replacement parts F.O.B. the factory where originally manufactured. Material and equipment covered hereby which is not manufactured by Seller shall be covered only by the warranty of its manufacturer. Seller shall not be liable to Buyer for loss, damage or injuries to persons (including death), or to property or things of whatsoever kind (including, but not without limitation, loss of anticipated profits), occasioned by or arising out of the installation, operation, use, misuse, nonuse, repair, or replacement of said material and equipment, or out of the use of any method or process for which the same may be employed. The use of this equipment constitutes Buyer's acceptance of the terms set forth in this warranty. There are no understandings, representations, or warranties of any kind, express, implied, statutory or otherwise (including, but without limitation, the implied warranties of merchantability and fitness for a particular purpose), not expressly set forth herein.

FCC Compliance (for the Em5R and Rm1)

This device complies with part 15 of the FCC Rules.

Operation is subject to the following conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

2. The Em5

About the Em5

The Em5 is a 5-channel, self-contained data logger with an optional radio telemetry module (Em5R). It is housed in a white weather-resistant enclosure, making it suitable for long-term outdoor operation. It is powered by 4 AAA-size alkaline batteries. Without the radio, a set of batteries can last for several years. With the radio operating in “broadcast” mode (model Em5R only), the batteries should last over a year, and in “query” mode they should last for about 1 month.

The Em5 setup

An Em5 system consists of the Em5 module, sensors, data collection apparatus (such as a computer or hand-held PC), and EchoLink computer interface software (included with Em5). The only sensors that will attach to the Em5 are ones built specifically for the system by Decagon. The sensors plug into the Em5's 5 channels and then take measurements according to your programmed sampling interval. The Em5 itself comes in two versions: one with radio capability (Em5R) and one without (Em5). The Em5R has a radio module installed that allows it to communicate telemetrically (once properly configured) with an Rm1 radio modem, which, in turn, connects to a computer. One Rm1 is capable of collecting data from multiple Em5Rs.

In both the non-radio Em5 and the radio-enabled Em5R, you can download data directly via an RS-232 cable that is plugged into the first channel (labeled “1” on the underside of the base plate) and connected to a computer. The EchoLink computer interface software allows you to program the time, date, and measurement interval times of the Em5, and download data. The PassiveTerm program is used in conjunction with the Rm1 as a simple terminal program that captures data as it is transmitted and allows it to be stored.

Em5 data logging scheme

Before collecting data with your Em5, you should set the measurement interval with EchoLink (see Chapter 4). This measurement interval controls how often data is recorded in the Em5's internal data storage. The interval you choose applies to all 5 ports on the Em5. It is not possible to have one port measuring sensors more or less frequently than another port. For most applications, a measurement interval of 60 or 120 minutes is appropriate.

The measurement interval works relative to the Em5's internal real-time, 24-hour clock. For example, when choosing a measurement interval of 120 minutes, the Em5 will store data every two hours, on the hour. The resulting data will show sensor measurements hourly at 12:00 am, 2:00 am, ..., 10:00 pm. Choosing a measurement interval greater than 720 results in one set of data stored per day.

For most sensor types, the Em5 makes a measurement from each of the 5 sensor ports every 60-seconds — regardless of the measurement interval value. When the Em5's internal clock reaches the time to store a reading,

the average value of all the 60-second sensor readings is stored. Therefore, if you set the measurement interval to 60, the Em5 will actually store an average of the past 60 sensor readings. If you choose an interval of 1440, the Em5 will store one value that represents the average sensor value for the entire 24-hour period.

For ECHO Rain Gauges, the value stored at the wake interval is the total tip events within the interval.

The Em5 internal data storage is non-volatile. Loss of battery power does not erase configuration settings or stored data.

3. Set-up and Installation

Installation of the Em5 system involves loading software on the computer that you plan to use for communicating with your Em5s, configuring the time, date, and operation of the Em5s, and installing the Em5s in the field with their relevant sensors.

Batteries

The Em5s are shipped with a new set of batteries. When the battery life indicator in EchoLink shows your Em5's batteries are less than 5%, you need to replace them. For information on replacing the batteries, see chapter 5. *Note: The internal data storage of the Em5 is non-volatile, so you will not lose data if you remove the batteries.*

Software

The EchoLink software that was included with your Em5 is a standard Windows application that installs in the typical fashion. Place the CD in your CD drive, and wait for it to auto-launch. If it doesn't launch by itself, click on the "setup.exe" file. Then follow the subsequent installation prompts. Occasionally, new versions of software will become available on our website. They can be accessed in the Em5 section of:

www.decagon.com/instruments/agdownload.html

You can find your current software version in the "About" option of the Help menu in EchoLink. If you are connected to the internet, EchoLink will check to see if there

is a newer version available. If there is, it will prompt you to the web page where you can download it

Configuring the Em5

Before field installation, the Em5 logger needs have parameters such as name, date, time, measurement interval, and communication mode set or defined. Also, the radio-enabled Em5R will not respond to radio contact until properly configured to do so. The Em5 can be directly connected to your computer using the 9-pin to 3.5-mm plug RS-232 cable (included with the logger). To accomplish this, do the following:

1. Run the EchoLink program.
2. Plug the 3.5 mm connector of the Rs-232 cable into Port 1 of the logger, and plug the 9-pin connector into the serial port of your computer. (**Note: Make sure EchoLink is running before connecting, or data loss may occur.**)
3. Set the correct COM Port address (See page 23)
4. Use the EchoLink program as described in Chapter 4 of this manual, to set the name, date, time, measurement interval, and radio mode of the logger. The optional Em5R and Rm1 radio modem may also be configured for communication (See **Radio Settings**)

Installing the Em5

The Em5 will serve as a collection station for up to 5 sensors. The Em5 is compatible only with sensors made by Decagon specifically for use with the Em5s, such as the ECH₂O water content probes, rain gauge, temperature

sensors, etc. To install the Em5 and sensors, do the following:

1. Install your probes as directed in the respective sensor's manual.
2. Plug the sensors' jacks firmly into the Em5 input ports. Unused inputs should be plugged to prevent dirt, water and insects from entering the case. Plugs are provided for covering unused inputs. ***Note: the ECHO Rain gauge should be plugged only into ports 2 through 5.***
3. On each side of the Em5, there are three loop-holes. Use these to fasten the Em5 to a mounting post using the included zip-ties or a similar fastener. Make sure it is installed in an upright position, with the 5 input ports underneath. In this position, rain and spray are shed by the enclosure and drip off without affecting the contents of the Em5 enclosure.

Cautions:

- Do not immerse the Em5.
- Make sure to install the Em5 upright, so that water cannot enter the input ports, which can result in damage to the logger.
- Do not install Em5R radio-enabled loggers near large metallic objects, as these can attenuate the radio signal.
- If the Em5R is mounted to a metallic post, be sure to use an antenna extension cable to mount the

antenna to the top of the post. This will maximize the transmit range of the Em5R.

- If you are using probes with cables longer than 16 feet (5m), there is a higher risk of damage to the Em5 if hit by lightning.

Range considerations

The range of the radio indicated in the specifications for the Em5R is the maximum range attainable with standard antennas and a clear and open path between the transmitter and the receiver. Both transmitter and receiver must be at an adequate distance above the ground.

Obstructions will attenuate high frequency radio signals, such as those from the Em5 radios. The higher the frequency, the greater the attenuation, so the usable range of the 2.4 GHz radios (available for use in locations outside the USA) is shorter than that for the 900 MHz units. Buildings, hills, vegetation, vehicles and other obstructions will shorten the radio's range — sometimes drastically so. Also, radio frequency (RF) interference in the environment around the radio can reduce the usable range.

You can greatly help the effective transmit range both by maximizing the height above ground of the Em5R's antenna and by using a directional Yagi antenna. Use our antenna extension cables to raise the height of the antenna. Different types of Yagi antennas and extension cables are available from Decagon. Also, maximizing the separation from RF sources such as electric motors, transformers, cell-phone towers, and vehicles will also increase your transmit range

Sensors

Sensors suitable for use with the Em5 are sold by Decagon. These include the ECH₂O soil moisture probe, the ECHO Rain gauge, temperature sensors, and Drain Gauge. Other sensors will become available in the future. The sensor is simply installed and plugged into the logger. Unused inputs should be plugged. ***Note: The ECHO Rain gauge must not be plugged into channel 1 of the Em5, since it causes conflicts with the internal hardware. Plug this sensor into channels 2 through 5 only.***

Radio Settings

For a group of Em5Rs to communicate with a radio modem (Rm1), both the channel number and the sub-channel of all units (including the Rm1) must coincide. Additionally, each Em5 must have a unique name.

Groups of Em5s with different channel numbers use different frequency-hopping sequences, and therefore experience minimal interference between groups.

Groups with the same channel numbers but different sub-channel numbers can interfere with each other, but can't communicate with each other. This interference can also cause additional battery drain.

Typically you pick a channel and a sub-channel, and set all Em5Rs and the radio modem (Rm1) to these numbers. Each Em5R is then given a unique name. If groups of Em5Rs are operating in adjacent fields within range of each other, and you want to access one group without disturbing the other, the two groups should be set to differ-

ent channel numbers. If the two groups are being contacted with the same radio modem (Rm1), the radio modem channel number needs to be changed to match each group before the Em5Rs in that group can be contacted.

The channel and sub-channel numbers are both set to zero when the radio is shipped from the factory.

These settings may be modified using the EchoLink software, as explained in chapter 4.

Setting up the Rm1 Radio Receiver

The Rm1 receiver module is specifically designed for communication between the Em5R (radio-enabled) loggers and a computer. Typically one Rm1 will serve as the radio modem for all of your Em5Rs, since it can collect data from many different Em5Rs. To set up communication between the Rm1 and the Em5Rs, do the following:

1. Connect the 6-in. antenna to the gold “RPSMA” plug on the Rm1.
2. Plug the 9-pin RS-232 cable (included with Rm1) into the RS-232 port on the Rm1, and plug the other end into an available serial port on your computer. See page 23 for more information on setting up your COM port correctly.
3. Plug in the AC adapter that came with your Rm1 and insert the 5.0 mm plug into the Rm1’s “DC in” jack. If you want your Rm1 to be mobile, contact Decagon for information on an adapter that attaches to your car’s 12V output (cigarette lighter).

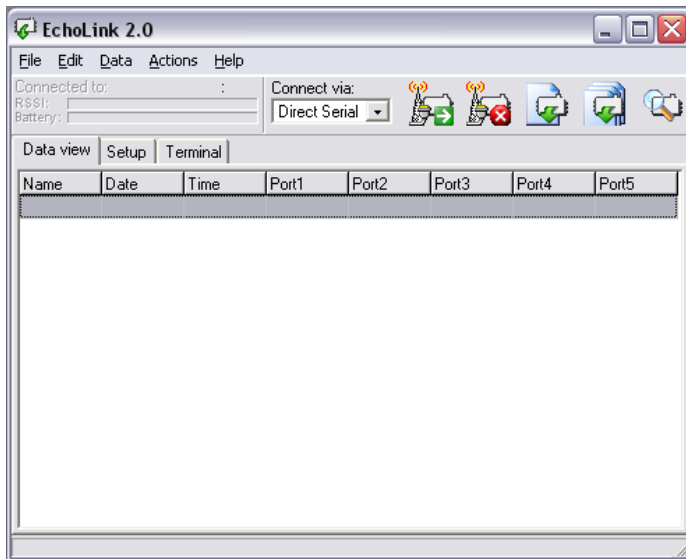
4. Move the switch to the “up” position to turn it on. If the serial port is active, the red LED is steadily illuminated, and blinks when data is being transmitted. The yellow LED blinks when it receives data.

Note: The standard antenna supplied with the Rm1 is for indoor use only. Please contact Decagon about an all-weather antenna if you choose to use your Rm1 outdoors.

4. Software

The EchoLink program

The EchoLink software provides a user-friendly interface for configuring, downloading and interrogating the Em5 logger. *Note: Do not connect the Em5's RS232 cable to your computer until you have the EchoLink program launched, or data loss may result.* To use the program, first install the EchoLink program from the CD-ROM that comes with your Em5. Launch the program and you will see the following screen:



The top right portion of the screen shows different icons for interacting with the Em5s. To the left is a battery indicator and a radio signal strength indicator (RSSI). Below are

three tabs: a text field where you will see data displayed as it is downloaded, a Setup tab that allows you to name and configure your loggers, and a Terminal tab that allows you to give direct commands to the logger via a terminal program. These functions will be described in detail further in this chapter.

Getting Started: Configuring the Em5

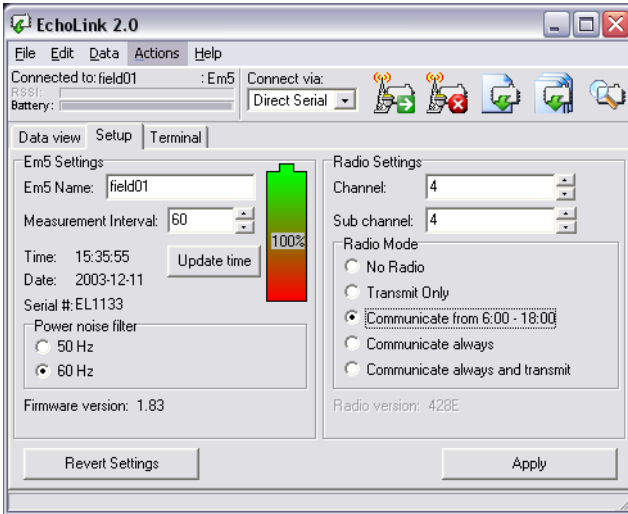
Before you begin using the Em5, you will need to determine the measurement intervals you want, as well as give it a unique station name that you can use to identify it. Follow these steps to set up the logger:

1. Set up EchoLink by selecting the *Preferences* dialog from the **Edit** menu. Select the COM Port you are using.
2. Plug the RS-232 cable into port 1 of the Em5 and select “Direct Serial” from the **Connect via:** dropdown menu at the top of the screen. Connect the other end of the cable into the COM port you specified in step one.
3. Click on the “Connect to Em5” icon on the upper right toolbar. A message will appear in the lower left corner of the screen indicating that it is trying to connect. Once connected, the top of the screen will show that it is connected, and the name of the Em5 that it is connected to is displayed.



The Setup Menu

1. Click on the “Setup” tab to configure and set up your Em5. The following screen will appear:



Configure your logger using the options listed in this menu. Below is a description of the options:

Em5 Name dialog box: Use this to give a unique name to your Em5, in order to distinguish it from other Em5s you may have. In the example above, this Em5 is named “Field01” You can use up to 8 alphanumeric values (no spaces) for this name.

Measurement Interval: Designates the desired time interval (in minutes) between reading the sensors connected to the Em5. In this example, readings are programmed to be made once an hour (every 60 min.).

Set Time: Press this button to program the Em5 with the same time and date as your computer.

Power Noise Filter: This is used to filter out electromagnetic noise caused by the AC electricity supplied by your electric utility to your home or office. Select the frequency for your country's standard (e.g. North America and Japan are 60 Hz, Europe and Australia are 50 Hz)

Channel/Sub-Channel: This sets the radio channel and sub-channel (for Em5R only). The channel and sub-channel must be the same for all Em5Rs and Rm1 to communicate. The Channel setting can be any number from 0 to 6, and the Sub-Channel setting can be any number from 0 to 65535.

Radio Mode: This selects the way the Em5 will transfer its stored data, either directly or via telemetry. Here is a description of the different modes:

- No radio: The Em5 will take and store measurements as configured, and will only download via direct connection with RS-232 and a computer or iPAQ-type device.
- Transmit only: After taking and storing each measurement, the Em5R will transmit the reading to a "listening" receiver. This mode is the most ideal radio mode in saving battery life, however it is only useful when the Rm1 or Datastation is available to receive the data. The actual transmit time is randomly delayed to help prevent two or more Em5Rs from transmitting at the same time.

- Communicate from 06:00-18:00: From 6:00 am to 18:00, the Em5R will “listen” for any available connection with an Rm1 every 45 seconds. If an Rm1 is actively transmitting, the Em5R will wait for a login command for a short time. This mode is useful for reducing battery consumption by not trying to make radio connections during the night.
- Communicate Always: The Em5R will function as described above on a 24-hour basis.
- Communicate Always and Transmit: Functions as described above, but will also transmit data as measurements are taken. This mode uses the most battery power, and is primarily for troubleshooting radio connection problems.

After you have set the desired values for the Em5, click on the “Apply” button in the lower right button. You are ready to install the Em5 in the field.

Note: While the Em5 is actively communicating (either via direct connection or radio), no sensor readings will be collected or stored.

Note for Em5R Communication: When the EchoLink software is already connected to an Em5R, clicking the “Connect” button again will cause the radio to log out of the currently active logger and search for another listening Em5R. If there are others listening, it will connect to one of them immediately. Once logged out, an Em5R will “sleep” for 10 minutes before being available again for communications.

Downloading Data

Once the Em5 is properly set up and installed, it will begin taking and storing measurements. Depending on how you have your Em5 or Em5R set up, it will either just store the data, or store and transmit the data. To download data, do the following:

1. For a direct connection, unplug any probe that may be present in channel one of the Em5, and insert the RS-232 cable. If using an Rm1 to connect to Em5Rs, make sure it is connected to your computer's serial port and the COM settings are set correctly.
2. Open EchoLink, choose your connection method (direct serial or Rm1 radio) in the "Connection via:" dropdown menu, and press the Connect icon:



3. Once connected to an Em5, press either the "Download New Data" icon



or the "Download All" icon:





Download: Downloads all data collected since the last download. The Em5's name will appear in the save window as the default file name. If "append to file" is selected in the Edit>Preferences menu, clicking "Save" will add the new data to the current data in the destination file. which displays the data as "raw" values. To see the actual downloaded data converted to sensor-specific data, you must export it first. The data can then be exported by EchoLink for the particular sensors attached (see the "Export" function in the **File** menu). The exported files can be imported by standard spreadsheet programs.



Download All: Downloads all data stored in the memory of the Em5. The Em5 name will appear as the default file name.



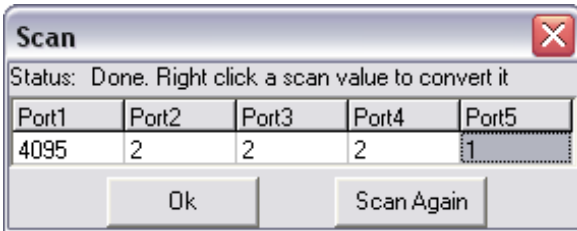
Disconnect: Logs you out of the current Em5. After logging out over the radio, the Em5R will not respond for 10 minutes in order to allow connections to other Em5R's. **Note: When downloading over a radio connection, be sure to press "disconnect" as soon as you are finished downloading data. EchoLink keeps the remote Em5R awake waiting for your commands until you disconnect. Therefore, leaving EchoLink connected over the radio will rapidly consume the Em5R battery life.**

Manual Measurement

If you want to initiate a reading manually (separate from the pre-programmed sampling interval) you can do so by either pressing the Scan icon



or by selecting “Scan Ports” from the **Actions** menu. The Em5 will take a measurement on all available ports, then display the following screen:



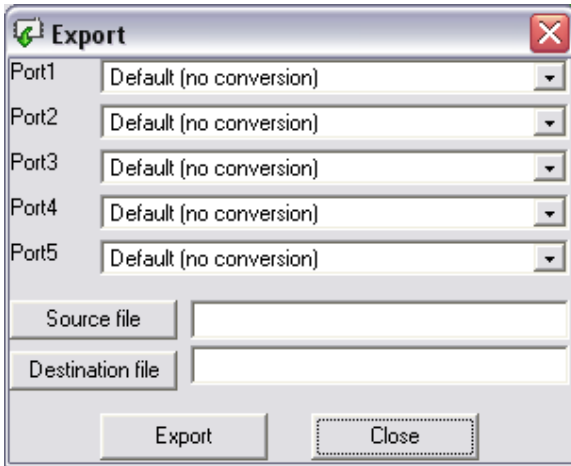
The 5 ports are displayed, along with the raw output values for each port. If nothing is plugged in, you will see values similar to the example above. *Note: in this example, the number “4091” appears in Port 1’s column because port one is directly connected to the RS232 cable and therefore has no sensor connected.* To convert the raw values to the desired units specific to the sensor connected to each respective port, right-click on the value and a drop-down menu will appear with different sensor type options. After selecting a sensor type, the data will be displayed in units for that sensor.

Menus

File Menu

File > Export:

Data downloaded from the Em5 is stored as comma-delimited, raw numbers. The Export function is used to convert these values to recognizable engineering units, such as millivolts (mV), water content, temperature, etc. From the File menu, select File > Export. Opening the Export window will display the following screen:



Ports 1 through 5 correspond to the 5 input channels on the Em5. Select the sensor in each Em5 port from the pull-down menu. If you leave a setting in a port window to “**Default,**” it will export the raw numbers. When you select a sensor type from the menu will change the raw numbers to the desired sensor measurement (water content, temperature, mV, etc.) using the factory calibration of the respective sensors. Sensor selection in each port will

be reset to **Default** each time the **Export** window is closed.

***Note:** Soil-specific calibration for Decagon's ECH₂O water content probes may differ from the factory calibration in some cases. If this is the case, use the **Default** setting to get data in mV and then apply the specific calibration in a spreadsheet program.*

A **Source** and **Destination** file must be selected to export data. The source file is the file specified when the data logger was downloaded. The destination file is the file in which you would like to store the exported data. Once the source and destination files are specified, click **Export**. The program will display "Export Complete" when finished. Click "OK" to return to the **Export** utility.

Click on the "Close" button to end an **Export** session.

Once exported, the data will be arranged in the following format:

Em5 name, Year, DOY, Time, Sensor 1, Sensor 2, Sensor 3, Sensor 4, and Sensor 5, where DOY is the day of the year and Time is minutes into a day (e.g. 350=5:50am, 1310= 21:50 (9:50pm)). Data can be split into columns using a spreadsheet program.

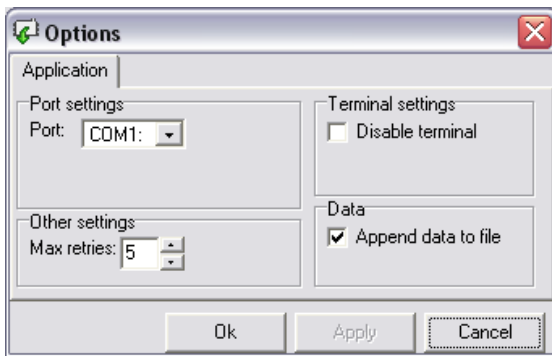
Export will allow you to export multiple files without closing the **Export** window. This is especially useful if there are several Em5 data files with the same sensor input channel configuration.

Edit Menu

The Edit Menu contains typical commands for cutting, pasting, and selecting data, as well as Preferences for interfacing with your Em5.

Edit > Preferences

The Preferences menu gives you several options. It allows you to select the COM Port you are using, and the number of times EchoLink tries a command when connected via radio. It also allows you to either enable or disable the Terminal tab from the main menu, as well as whether or not to append new data to the same file when downloading data from the Em5.



COM Port Settings: When connecting directly to the Em5 or using the Rm1, the computer will communicate using one of its communication ports. The default port is COM 1. Other ports can be selected using the pull-down menu and selecting the desired port. ***Warning: Communication between the computer and Em5/Rm1 will not occur if the COM port is set improperly.***

Note: PDA desktop communication (“HotSync”) software that runs in the background of your PC may interfere with your computer’s ability to communicate with the Em5. If you encounter problems with communication, make sure you close any PDA synchronization utility that may be running in the background.

Data Menu

The Data menu has three options: “Download Data,” “Download New,” or “Erase Em5.” The “Download Data” option functions the same as clicking on the “Download All” button from the main menu. This will download all the data stored in the Em5. Similarly, the “Download New” option, like the “Download New” button in the main menu, will only download the newest data that has been stored since your last download.

To erase all the data stored in the Em5, select “Erase Em5.” When you select this option, a dialog box will appear, warning you that all the data will be erased if you proceed.

Actions Menu

The first three options in the Actions Menu (Connect, Disconnect, and Scan Ports) are identical to the buttons on the main menu. For more details on these items, refer to the “Downloading Data” section earlier in this chapter.

Device Test

This option checks the integrity of the Em5’s operating code. You must first connect directly to the Em5 using the RS232 cable before performing this test. If the code is

found to be corrupt or damaged, the program will alert you.

Telemetry Test

This option only works when connecting to an Em5R logger via the Rm1 radio modem. This test checks to see how well you can receive data from the Em5R at the current position and distance, which will give you a better idea of any signal attenuation before you proceed to make a permanent installation. To perform the Telemetry test you must first be connected to an Em5R remotely (through an Rm1 Modem). **Note: This test rapidly consumes the remote Em5R's battery power, so be careful in the length of time that you take to perform this test.**

Reset Device

This option will reset the Em5 to its factory default state. Your data will be areased, but your configuration settings will be left intact. This is a useful tool if you are experiencing any anomalies or inconsistencies in the operation of your Em5.

Note: Proceeding with the reset will delete all data, so make sure any data has been downloaded out of the Em5 before initiating a reset.

Initialize Radio

This option initializes, or resets, the Em5R's radio module. This is useful if you suspect problems with the Em5R's radio transmission.

Set Date/Time

This function works the same way as the "Update Time" button in the Setup menu. When you select this action,

EchoLink will set the Em5's time and date to be the same as the time and date on your computer.

Rm1 Setup

This option is for setting the channel and sub-channel of the Rm1, like you do in the Setup menu for the Em5R. In order for the Rm1 to communicate with the Em5Rs in your desired network, both the Channel and Sub-channel values of the Rm1 and Em5Rs must coincide.

First, connect the Rm1 to the correct COM port on the computer using the serial cable provided. Once connected, select "Rm1 Setup" from the Actions menu and enter the same Channel and Sub-Channel values as the Em5Rs you want to communicate with. To save these settings in the Rm1, select "Apply." To discard changes and return to EchoLink, select "Cancel."

Help Menu

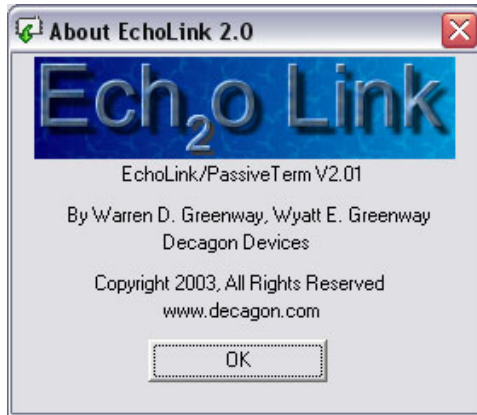
The Help Menu contains "EchoLink Help", which is an HTML-help program that opens in your web browser. It has a table of contents with brief explanations of how EchoLink works, as well as some basic setup instructions and troubleshooting guides.

Check for Updates

This option is useful in determining if you have the newest available version of EchoLink. If you are connected to the internet, EchoLink will check to see if there is a newer version available. If there is, it will prompt you to the web page where you can download it.

About

The About option tells you information about the EchoLink program, including the current software version. When you select the “About” in the Help menu, the following screen will appear, showing the current version of software:



5. Maintenance

If installed correctly, the Em5 requires little maintenance. The main requirement is that batteries need to be replaced when their charge becomes too low. The Em5s are shipped with a new set of batteries. We strongly suggest you use high-performance alkaline batteries when possible, in order to maximize the life of your Em5. When the battery life indicator in EchoLink shows your Em5's batteries are less than 5%, you need to replace them.

To change the batteries, do the following:

1. Unplug sensors from the Em5.
2. Disengage the tabs on each side of the bottom plate, and pry the bottom out of the case.
3. Slide the logger and batteries out of the case. Replace the batteries, making sure to install them with the proper polarity.
4. **IMPORTANT: Once the new batteries are installed, press the silver reset button on the battery side of the Em5 board to make sure it starts up properly.**
5. During the time that the batteries are being changed, all current settings and data will be saved, but readings will not be taken.
6. The Em5 clock is not saved when changing the batteries. Therefore, after changing the batteries, connect to

the logger with EchoLink and push the “update time” button to set the time correctly.

7. When sliding the Em5 assembly back into the case, take care that it is oriented correctly.

Removing the Radio Module

The Em5R comes with the radio module pre-installed on the data logger board. Should you need to remove it for any reason, always disconnect at least one battery from each of the two battery holders. This will power down the radio and avoid any damage.

***Note:** Removing the radio module from the data logger can cause the radio module to “freeze” and stop functioning properly. After the radio is replaced, press the silver reset button on the battery side of the data logger board.*

Appendix A

Operation using Terminal

The Em5 can be accessed directly with using the “Terminal” screen in EchoLink or terminal software like *Windows Hyperterminal* for special applications. Following are instructions on how to operate the Em5 using terminal commands.

Commands

To directly initiate communications with an Em5 using an RS232, connect the data logger to the computer COM port using the Em5 serial cable, and look for the Em5 to return a “>” on screen. If it does not, check the RS-232 connection between the Em5 and computer, as well as the COM port settings.

To initiate communications with an Em5R using an Rm1, make sure the Rm1 is operating and connected correctly to your computer, and is set to the same channel and sub-channel values as the Em5R you are trying to communicate with. In the terminal mode, you will need to send a “wake-up” signal to the Em5R. This is done by holding down the “Enter” or the “w” key on your keyboard for about 50 seconds. Note: Before doing this, change your keyboard repeat rate to “maximum” in the Keyboard section of your computer's Control Panel. After the 50-second “wake-up” command, type “query” to determine

which Em5R has responded. The name of the first Em5R to respond will appear on the screen. To log in to that particular Em5R in order to download and give further commands, press the Enter key and then type "login *name*" (where *name* is the name returned by the Em5R). Once you log in to the Em5R, a ">" will appear on screen. If it does not, check the computer and COM port settings. If you want to log in to a different Em5R, log in to the current Em5R, type "logout" and then type "query" again. Repeat this process until you have connected to the desired Em5R.

Once you have established communications, you can use the following list of available commands:

time	show time and date
scan	show input voltages
show	show system data
volt	show battery voltage (mv)
dump [-a]	dumps new data stored in memory -a all data in memory
erase	erases data from memory
logout	quit communicating (radio off for 10 min)
set -t hh:mm	sets time (sec = 0 on enter)
set -d yy-mm-dd	sets date
set -i #####	sets Em5 name (1..8 characters)
set -w #####	sets measurement interval in minutes (1..1440)
set -r ##	sets radio mode 0 = no radio 1 = transmit only 2 = 6am-6pm communication;

3 = communicate always;

4= communicate always and transmit

time

Shows the Em5's current time and date.

scan

Allows you to take a direct reading of the input voltages on all channels. Values shown on screen are in raw units. Multiply by 0.61 to get mV value. *Note: When the Em5 is connected to the computer with a serial cable, the reading on channel 1 will be the RS-232 voltage.*

show

Shows the system data, such as the operating system name and version, station identification, and current measurement and radio settings. Following is an example:

Decagon Flash Operating System, by
Warren D. Greenway Copyright 2003, All
rights reserved.

```
ID: field1   Version: 1.83  
Radio: 1     Wake:60     Resets: 0
```

volt

Shows the current voltage of your Em5, in millivolts. A fully charged set of batteries should show a voltage of about 3000mV. When the battery voltage reaches 2700mV, the batteries must be changed.

dump [-a]

“**dump**” downloads all new data collected since the last download.

“**dump -a**” will download all data in the Em5's memory.

Data output from the Em5 is in a comma-delimited format. The data can be saved to a file. In the comma-delimited format, MS Excel and other spreadsheet programs will recognize each data point in a line separated by a comma as a new column. *Note: The Em5's station name will not be displayed on the front of each line in this mode. This features is only found in the EchoLink software.* The columns are labeled as follows:

Column 1: Days since Jan. 1, 2000; e.g. Feb 4, 2002 would be "765" (2 years = 730 plus 35 days)

Column 2: Minutes into a day; e.g. 13:30, or 1:30 pm, would be "810" (13 hours = 780 plus 30 minutes)

Columns 3 to 7: Raw numbers from the Em5's Analog to Digital Converter (ADC). The Em5 stores data in raw ADC numbers. These values can be easily converted into mV values by multiplying by 0.61.

Column 8 (Radio Mode 1 only): Em5 battery voltage, in % of capacity. When the voltage is below 2530 mV, batteries should be changed.

erase

Erases all data from the Em5's memory.

logout

Logs out from the current Em5. When connected over the Rm1 radio receiver module, the logout command will cause the Em5 to sleep (not respond to commands over the radio) for 10 minutes.

set -t

Sets the time. To set the time, type “set -t ” followed by the time (e.g.: set -t 14:30). Time must be in 24-hour (a.k.a. military) format. The dash in front of the **t** is necessary, as is the colon separator between hours and minutes.

set -d

Sets the date. To set the date, type “set -d” followed by the date in year-month-day format (e.g.: set -d 2002-05-23). The dash between numbers is necessary.

set -i #####

Sets the name for an Em5. To find its current name, type “show.” You should then see an id appear on the screen along with other information. To rename it, type “set i -XXXXXXXX” (where the X’s are the desired name). The Em5 can have any alphanumeric name of up to 8 characters (no spaces). All Em5R radios within talking distance of each other must have unique names to prevent interference with each other when they communicate with the Rm1 radio receiver. *Note: Station names are case-sensitive.*

set -w

Set the measurement interval (number of minutes between each measurement). Valid values are 0 to 1440 (1 day). If the interval is set to zero, no reading is recorded. For measurement intervals longer than 1 minute, the stored values are the average of readings taken at 1 minute intervals. For example, if the measurement interval is set to 60, one set of readings is recorded each hour with each value being the average of 60 readings taken during that hour.

set -r

Sets the radio mode. If you don't have the radio option (Em5R), set this to 0 (no radio) by typing “set -r 0”. In this mode (0), battery life is about 4 years. If you have an Em5R (radio-capable logger), there are three settings available: 1 (transmit only), 2 (transmit/receive from 6am - 6pm), and 3 (transmit/receive 24 hours/day). The first option (transmit only) sets the Em5 to transmit its data to an Rm1 every time a measurement is made. There is a built-in random delay between the measurement time and the transmit time so that several Em5's can transmit to a single radio modem without interference. If you transmit a reading once per hour, battery life in this mode should be over 1 year.

Modes 2 and 3 are for contacting the Em5Rs and dumping the data using a computer and the Rm1 radio receiver module. In these modes, the Em5 “wakes” for 150 milliseconds every 45 seconds to listen for a signal. If a signal is detected, it stays “awake” for 60 seconds to await commands. Once an Em5R has responded to the Rm1, any of the commands listed above can be sent. To close the session, type *logout*, after which the Em5 will be inactive for 10 minutes (to allow other radios within range to be interrogated). These modes require the most power. In mode 3 (activated 24 hours a day), battery life is about 1 month. Mode 2 (no operation from 6:00 pm to 6:00 am) is often more preferable, since most users do not need to contact the logger at night. Therefore, this mode should result in a battery life of around 2 months.

Appendix B

Em5 Specifications

Input Channels: 5, with 12-bit A/D resolution and 2.5V excitation on each channel. 3.5mm “stereo-plug” style connector.

Data Storage: 49KB (145 days @ 1 scan/hour)

Memory Storage: Non-Volatile Flash Data

Communication:

- RS-232 capability on Port 1
- Optional 900MHz or 2.4GHz spread spectrum RF communication (model Em5R); up to 5-mile line of sight range with 900Mhz model, 1.5 mile line of sight range with 2.4Ghz model.

Power Requirements: 4 AAA alkaline batteries

Enclosure: Weatherproof, impact-resistant NEMA 3R

Operating Environment:

-10°C to 50 °C, up to 100% RH

Dimensions:

8.7cm Length x 6.2cm Height x 3.5cm Width

Rm1 Receiver Specifications

Frequency-hopping Spread-spectrum Radio:

North America: 902-928MHz ISM

Australia and Israel: 915-928 MHz

Worldwide: 2.4GHz ISM

Serial Data Interface: RS-232

Supply Voltage: 7-18 VDC (AC Adapter supplied)

Current Consumption: 70-210mA

Dimensions: 7.9cm x 13.9cm x 3.8

Weight: 6.9 oz. (195.6g)

Operating Environment: 0 - 70 °C, 10-90% RH

FCC info:

The Em5R and Rm1 (900MHz) contain transmitter module FCC ID:OUR9XSTREAM. The 2.4GHz Em5R and Rm1 contain transmitter module FCC ID:OUR24XSTREAM. These devices comply with Part 15 of the FCC rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2), this device must accept any interference received, including interference that may cause undesired operation.

Appendix C: Em5 CE Compliance

Application of Council Directive:	89/336/EEC
Standards to which conformity is declared:	EN61326 : 1998 EN55022 : 1998
Manufacturer's Name:	DecagonDevices, Inc.
Type of Equipment:	Data collection system.
Model Number:	Em5
Year of First Manufacture:	2002

This is to certify that the Em5, manufactured by Decagon Devices, Inc., a corporation based in Pullman, Washington, USA meets or exceeds the standards for CE compliance as per the Council Directives noted above. All instruments are built at the factory at Decagon and pertinent testing documentation is freely available for verification.

Appendix D: Em5R and Rm1 CE Compliance

Application of Council Directive: 89/336/EEC

Standards to which conformity is declared: EN 300 826, EN 60950

Manufacturer's Name: DecagonDevices, Inc.

Type of Equipment: Radio-enabled data collection system

Model Numbers: Em5R, Rm1

Year of First Manufacture: 2002

Restrictions:

France: Current regulations in France stipulate that these devices may be used indoors only. Outdoor usage on private property is subject to authorization from the French Telecommunications Regulatory Authority. Outdoor usage on public lands is currently prohibited. For more information see <http://www.ero.dk>.

Appendix E: ECH₂O soil moisture probes

The most common use for the Em5 is monitoring soil moisture using Decagon's ECH₂O probes. This appendix is a description of the specifications and operation of the ECH₂O probes.

ECH₂O Specifications

Measurement Time: 10ms (milliseconds)

Accuracy:

- Typically $\pm .03$ m/m ($\pm 3\%$)
- With soil-specific calibration $\pm .01$ m/m ($\pm 1\%$)

Resolution:

- $0.002\text{m}^3/\text{m}^3$ (0.1%)

Power:

- Requirements: 2.0VDC @ 2mA to 5VDC @ 7mA
- Output: 10-40% of excitation voltage (250-1000mV at 2500mV excitation)

Operating Environment: 0 to 50°C

Range of Measurement:

0 to saturated volumetric water content

Probe dimensions:

(model EC-20): 25.4cm x 3.17cm x .15cm

(model EC-10): 14.5cm x 3.17cm x .15cm

Cable length: 10ft standard, extension cable available

Connector type: 3.5 mm plug

Warranty Information

The ECH₂O has a 30-day satisfaction guarantee and a one-year warranty.

About the ECH₂O

The ECH₂O probe measures the dielectric constant of the soil in order to find its volumetric water content. Since the dielectric constant of water is much higher than that of air or soil minerals, the dielectric constant of the soil is a sensitive measure of water content. The ECH₂O probe has a very low power requirement and high resolution. This gives you the ability to make as many measurements as you want (even hourly) over a long period of time (like a growing season, for example), with minimal battery usage.

Features

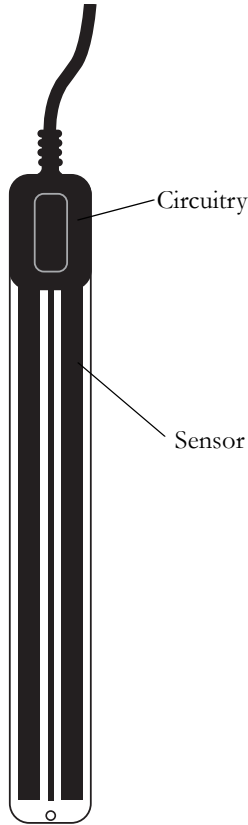


Fig.1: ECH₂O probe diagram

Wiring Diagram

3.5mm plug wiring

The ECH₂O probe comes with a 3.5mm “stereo-plug” style connector. This allows for rapid connection directly to Decagon’s Em5 or ECH₂O Check. Below is a diagram showing the wiring configuration for this connector.

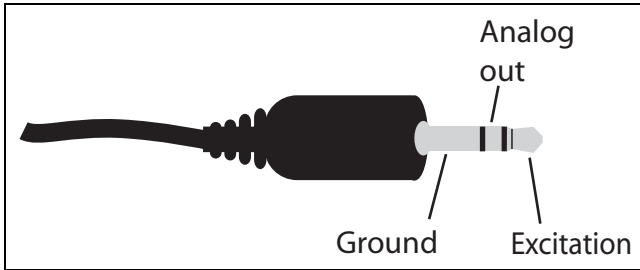


Fig. 2: ECH₂O plug wiring configuration

Installing the ECH₂O Probe

When selecting a site for installation, it is important to remember that the soil adjacent to the probe surface has the strongest influence on the probe reading and that the probe measures the *volumetric* water content. Therefore any air gaps or excessive soil compaction around the probe can profoundly influence the readings. Also, do not install the probes adjacent to large metal objects such as metal poles or stakes. This can attenuate the probe's electromagnetic field and adversely affect output readings.

Procedure

When installing the ECH₂O probe, it is best to maximize contact between the probe and the soil. There are two methods to accomplish this:

1. Use Decagon's Probe Installation Kit to install the probe. This kit has a custom-shaped blade to make the insertion in the soil, then another tool to place the probe into the insertion. For deeper installations, use an augur to reach the desired depth, then use the Installation kit with extension rods to install the probe.

2. Use a thin implement like a trenching shovel, gardening spade, or flat bar to make a pilot hole in the soil. Then insert the probe into the hole, making sure the entire length of the probe is covered. Finally, insert the shovel again into the soil a few inches away from the probe, and gently force soil toward the probe to provide good contact between the probe and the soil. For deeper installation, excavate down to the level you wish to measure, then install the probe as described.

Orientation

The probe can be oriented in any direction. However, orienting the flat side perpendicular to the surface of the soil will minimize effects on downward water movement.

Removing the Probe

When removing the probe from the soil, ***do not pull it out of the soil by the cable!*** Doing so may break internal connections and make the probe unusable.

ECH₂O Probe Calibration

The ECH₂O probes come pre-calibrated for most soil types. If, however, your soil type has high sand or salt content, the standard calibration will not be accurate. In such cases, you can perform specific calibrations for your individual soil types. The standard calibration for the standard 25cm length (EC-20) ECH₂O probes when used with an Em5 is

$$\theta \text{ (m}^3\text{/m}^3\text{)} = 0.000424 * \text{raw} - 0.29$$

and for the shorter (model EC-10) probes is:

$$\theta \text{ (m}^3\text{/m}^3\text{)} = 0.000571 * \text{raw} - 0.376$$

where θ is the volumetric water content and “raw” is the raw data output. **NOTE!** *This calibration is only for use with Em5 data loggers.*

Extension cables

Decagon supplies 50-foot (15.25m) and 10-foot (3m) extension cables for use with the ECH₂O probe. You can safely connect up to 3 of the 50-foot cables without signal attenuation. For most applications, we recommend sealing the connections from the elements to maintain a good connection and to prevent corrosion. Decagon provides adhesive-lined heat-shrink for this purpose. To seal a connection between two extension cables using the heat-shrink, simply ensure that the heatshrink is covering the connection, then heat it using a heat-gun, blow-dryer or a lighter until it shrinks tight to the connection. **Note:** *If using a lighter, place the heat-shrink well above the flame to avoid melting the heat shrink and the connector.* Additional heat shrink is available from Decagon.

Troubleshooting the ECH₂O probe

If you encounter problems with the ECH₂O probe, they most likely will manifest themselves in the form of incorrect or erroneous readings. Before contacting Decagon about the sensor, do the following:

- Check to make sure the connections to the data logger are both **correct** and **secure**.
- Ensure that your data logger's batteries are not dead or weakened.

Em5 User's Manual

Appendix E: ECHO soil moisture probes

If you encounter problems that aren't due to the Em5, please contact Decagon at (509) 332-2756 and at **echo@decagon.com**.

Appendix F: Other Sensors

ECHO Temperature Sensor

The ECHO Temperature sensor is available for use in soil or in the air. It can be connected directly to any channel in the Em5 or Em5R for long-term monitoring of temperature.

Specifications:

Sensor Dimensions: 6mm diameter x 375mm long

Cable length: 3.05m

Temp. Range: -20 °C to 60 °C

Accuracy: ± 0.5 °C

Resolution: 0.1 °C

If you are using the ECHO Temp sensor in air, we strongly recommend that you use it in a radiation shield. A good type for this kind of sensor is available from Davis Instruments, Model 7714.

ECH₂O Rain Gauge

The Echo Rain Gauge is a self-emptying and frostproof electronic rain gauge that can be connected to your Em5. The ECHO Rain Gauge is made of durable weatherproof plastic and can withstand temperatures from below freezing to extreme heat, and has an accuracy of $\pm 2\%$.

The rain is collected by the funnel and runs into a self-emptying spoon, which automatically tips and is emptied when it reaches a volume of five millimeters of water

(which corresponds to 1ml of precipitation). Each time the spoon empties, a measurement is sent and recorded by the Em5. Exported data will be displayed in terms of millimeters of precipitation.

Drain Gauge

Decagon's Drain Gauge is an instrument that is designed for long-term monitoring of water movement and chemical leaching below the root zone. Water filters through a soil column and collects in a sampling reservoir. The water fills the height of the reservoir, and the water level is monitored by an electronic water level gauge. When the water level reaches the top of the siphon tube, the water empties and the change in water volume is recorded by the Em5. The emptied water then drains into the sampling reservoir.

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