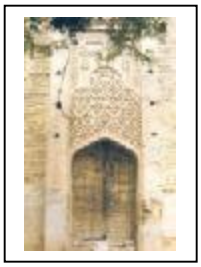
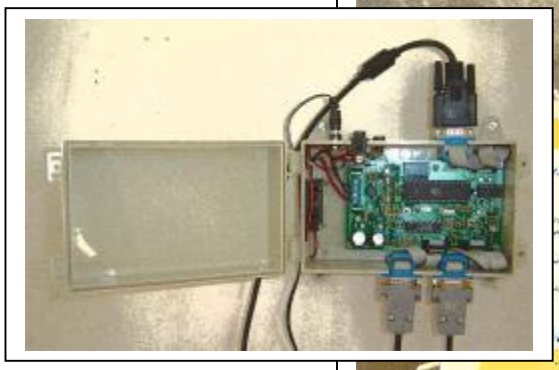


IDRG WLL-2CH

COMPUTER-BASED WEIGHING LYSIMETER LOGGER

Application Note



- **2-CHANNELS LYSIMETER LOGGER**
- **INCLUSIVE SOFTWARE**
- **GRAPHICAL PRESENTATION**
- **16 bit RESOLUTION ON EACH CHANNEL**

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Introduction

A lysimeter (evapotranspirometer) is a vessel or container placed below the ground surface and filled with soil, on which vegetation can be cultivated. It is a multi-purpose instrument for the study of several phases of the hydrological cycle under natural conditions. Estimates of evapotranspiration (or evaporation in case of bare soil) can be made by measuring and balancing all the other water budget components of the container (i.e. precipitation) underground water drainage, and change in water storage of the block of soil. Usually, surface runoff is eliminated. Lysimeter can also be used for the estimation of the potential evaporation of the soil or of the potential evapotranspiration of plant-covered soil, if the soil moisture is kept at field capacity.

Lysimeters are being used extensively in agriculture, environmental science and hydrology as a means of measuring complex soil-water-chemical-plant interactions. Weighing lysimeter is a fully automatic system designed for monitoring weight changes in plant growth systems allowing researchers to assess information such as evapotranspiration and soil nutrient uptakes. The heart of the weighing system is a series of **load cell** sensors which can be connected together to take a continuous series of measurements over a given time period which is programmed by the researcher. Readings can be taken from every second to readings every matter of days.

Software

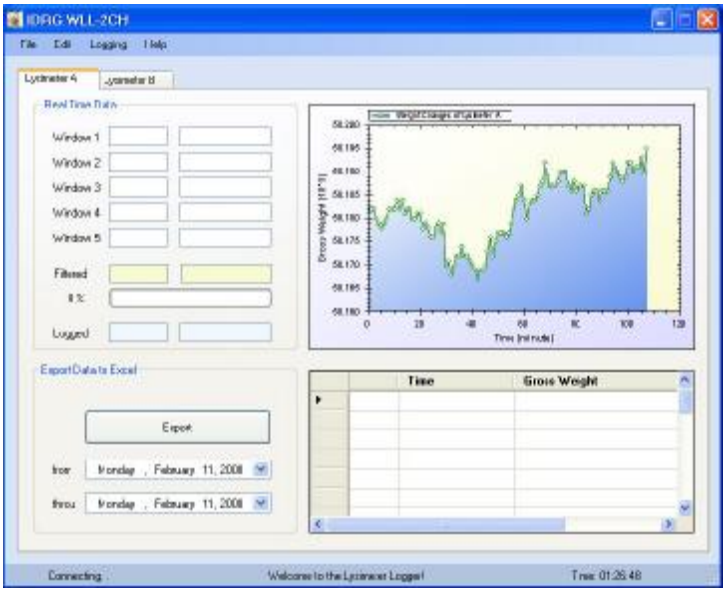
The IDRG WLL-2CH software is very handy to program the logging intervals of the load cells and to store a large amount of data. The data is logged as mass in kg with a resolution of about 0.003 percent of total mass (adjustable). The information collected allows for quantifying precisely the water consumed by the plants and to visualize the evolution of water consumption rate as water stress evolves.

System Requirements:

Pentium III, 256 Mb RAM, 24Mb free hard disk space for installation files and enough space for data storage depending on the logging period, WinXP/2000

Installation:

Run Setup.exe from the companion CD and set the target folder and shortcut name. After software installation, please run it, interconnecting the device and your PC using the RS232 cable. Providing there is no problem, "Connected" will be appeared on the strip bottom the window. The system can now be programmed and used.



Software Review:

A. Menu:

1. File Menu

a. Exit: to exit the Lysimeter Logger software.

2. Edit Menu

a. Options

- Communication:

- **Port Settings:** COM port number is set based on the port of PC to which RS232 cable is connected.
- **Logging:** Enabling this option makes the program log weight data (e.g. evapotranspiration).

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- **Lysimeter A/B:** for setting the properties of data manipulation (weight data obtained from each lysimeter).
  - § **Filter:** To decrease the noise level of data an averaging method must be utilized. The Rolling-moving average is a recommended one for lysimetery applications; but, placing an appropriate threshold value is of great importance depending on the evapotranspiration rate.
  - § **Calibration:** Due to different factors affecting the precision of the weight values, data taken needs to be calibrated. A linear calibration method ($y = mx + b$) might compensate for such source of error. The calibration procedure is to place known weights on the lysimeter and then to record the resultant pressure changes. Measurements are made both as weight is added and removed.
  - § **Logging Interval:** specifies the frequency of logging. Minimum and maximum logging intervals are 1 min and 1440 minutes, respectively. Sampling frequency is different from the logging one, having been programmed to be 3Hz (3 readings per second).
  - § **Initial Value for Weight:** This dead value is subtracted from gross weight measured.

- **General:**
  - § **Merlin:** Merlin is a narrator introducing the system. It appears whenever the software launches. You can disable this feature.

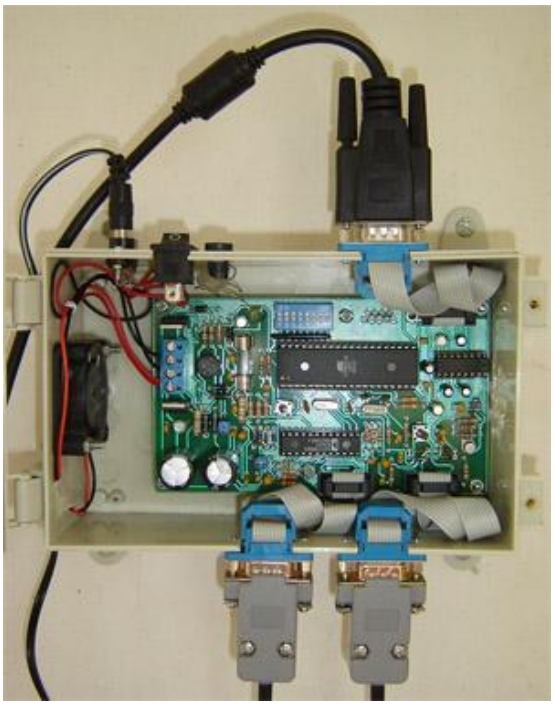
3. Logging Menu:
a. Lysimeter A/B: for starting a sampling process. The result would be plotted and/or logged in real-time depending upon the user's option.
b. Restart the Application: restarts the software. All variables are reloaded with their initial values.

B. Lysimeter A/B Tab:
1. Export Data to Excel
To export visualized data to Excel for further use and analysis.

Hardware

Controller

The controller is a board made up of an analog-to-digital converter which is a 24-bit Delta-Sigma ADC and an AVR microcontroller. The micro performs the basic weigh scale function, sending data to a personal computer (PC) for analysis and debugging. Conversion results from the ADC are communicated to the PC over the RS232 bus. This data can be viewed on a PC in real-time, using the software (i.e. graphical user interface).



Red LED (Power Indicator):
When you connect the controller to the power, after flipping the switch on, this LED turns on.

Connectors:
There are three D-connectors on the housing of the controller. Two of them are devoted to the communication with lysimeters and one to interface with PC which is separate from the others.

Mounting Location of controller:
Please install the controller at the following places:

1) Where the temperature is within operating

temperature range (-10 ~ +50°C).

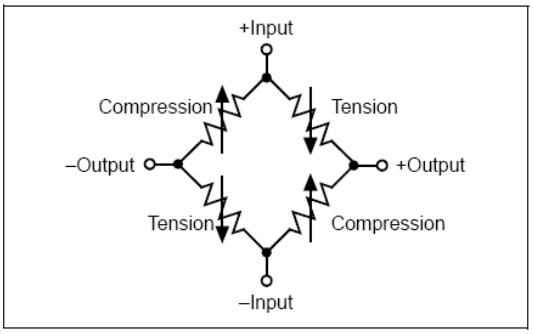
2) Where the cable length between the sensors and controller is minimum.
3) Where easy to check the operation status.

Please avoid following places:

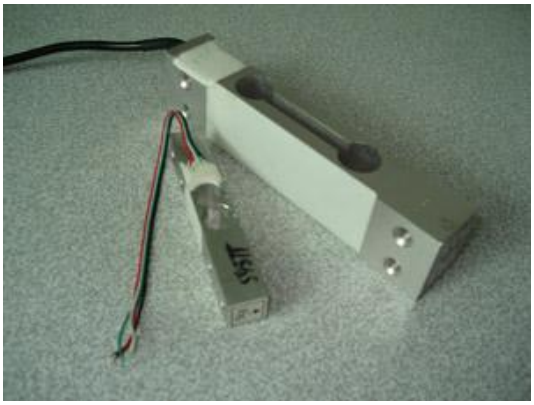
1) Any places of direct sunshine.
2) High voltage or high current nearby.
3) Where there is SCR (Silicon-Controlled Rectifier) Control Unit.

Load Cell

There are many different types of sensors whose underlying realization is based on a Wheatstone bridge. Strain gauges are one such sensor. As a material is strained, there is a corresponding change in resistance. In many cases, each side of the Wheatstone bridge may respond to the strain by lowering or increasing in resistance.



A load cell is an electronic device that measures the deformation of a piece of metal by means of a strain gage (i.e. the resistance changes when stretched). Load cells come in a variety of shapes, sizes, capacities, and costs. For lysimetery applications, the focus will be on a fairly small sub-class of load cells that are fully active and temperature compensated.



There are a variety of important parameters for load cells. The input impedance is important as well as the output impedance. In addition, it is critical to know the change in output voltage per volt of excitation, the change in output voltage versus temperature with no load, and the change in output voltage versus temperature with a full load. Load cells have also a safe overload limit and a maximum overload limit. If the load exceeds the maximum overload, then the load cell may be permanently damaged. In addition, load cells have (or may have) a linearity error specification, a hysteresis specification, a repeatability specification and a creep specification.

Considerations

Accuracy

The accuracy of the current weighing system is high enough to measure small weight increase which can be for instance attributed to dew formation. Dew formation takes place, if the temperature of the surface it forms on falls below the dew point temperature. To check if the weight gain was indeed a result of dew formation, the minimum temperature observed and the dew point temperature obtained from data for air temperature and relative humidity are compared.

Ratiometric Design

For best performance, ratiometric measurement techniques (same reference source for bridge excitation and ADC reference) have been employed in the reference design. The output accuracy of the load cell is determined by the excitation voltage of the bridge. The bridge output is directly proportional to the excitation voltage, and any drift in the excitation voltage produces a corresponding drift in the output voltage. By using a voltage that is proportional to the bridge excitation voltage as the ADC's reference

source, there is no loss in measurement accuracy if the actual bridge excitation voltage varies. This *ratiometric* connection removes the effect of drifts and very low-frequency noise in the excitation source.

Rolling-Moving Average

The measurements are condensed to T-minute (adjustable) Rolling-Moving averages to reduce external effects, for example caused by wind (oscillation of the lysimeter weight) or short term weight increases (due to passing animals etc.). This filter that is embedded in the software averages a number of points from the input signal to produce each point in the output signal. The input to the filter is taken directly from the controller. Operating on the most recent M data points, the N data points greater or smaller than that of the specified threshold are deleted from the data window. The remaining M – N points are averaged, as shown in the equation:

$$y[i] = \frac{1}{M - N} \sum_{j=0}^{M-(N+1)} x[i + j]$$

Discrete Fourier Transform

Many factors limit the final precision of evapotranspiration data obtained from lysimeter. In general, to enhance the accuracy of weighing lysimeters, DFT time filtering technique is a useful tool. This is mainly carried out to remove or to retain variations at particular bands of frequencies from the time series (e.g. evapotranspiration data gathered over a period of time). Providing enough information about the sources of interfering factors are exist, data manipulation in real-time can improve the validity of data recorded.

Product Limited Warranty

The IDRG WLL-2CH is warranted to the original purchaser to be free from defects in materials and workmanship under normal installation, use and service for a period of one (1) year from the date of installation.

The obligation of our company under this warranty is limited to the repair or replacement (at our option), during the warranty period of any part which proves defective in materials or workmanship under normal use and service, provided the product is returned to us (address below the page).

This warranty gives you specific legal rights.

Every effort has been taken to ensure the accuracy of this specification, however we do not accept responsibility for damage, injury, loss or expense resulting from errors and omissions, and we reserve the right of amendment without notice.

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