Software Environment for the Laser Precipitation Monitor

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Abstract: - The disdrometer produced by Thies Clima measures rainfall and provides raw data to be processed in order to retrieve the desired information. The paper describes a new software developed in order to extend the capabilities of a Thies Clima disdrometer. The new application is designed to analyze the raw data and create graphs of the statistical rain drop distributions.

Key-Words: - editing, disdrometer, Visual Basic, programming, rain, simulator.

1 Introduction

The main objective of this paper is to present a solution for computing and showing results of rainfall measurement. The measurement equipment used is a Disdrometer, built by Thies Clima.

This paper analyzes the limitations and disadvantages of the disdromteter as well as the program provided with the equipment, and provide a solution which is more fit to the results we need to obtain.

2 General Characteristics Of The Disdrometer

The Laser Precipitation Monitor [1] serves as measuring data transmitter, and is well-suited for the measurement and detection of different types of precipitation such as drizzle, rain, hail, snow and mixed precipitation.

The acquisition comprises the types of precipitation, intensity and the spectrum. All measuring values are available for the user via an RS 485/422 interface. In addition, the instrument is equipped with two digital outputs (optocouplers), which indicate, for example, the amount and state of precipitation. The optical components are equipped with an integrated heating.

2.1 Mode Of Operation Of The Laser Precipitation Monitor

A laser-optical beaming source (laser diode and optics) produces a parallel light-beam (infrared, 780nm, not visible). A photo diode with a lens is situated on the receiver side in order to measure the optical intensity by transforming it into an electrical signal (figure 1).

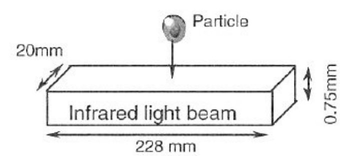

Fig. 1 Measurement of the precipitation particle

When a precipitation particle falls through the light beam (measuring area 45.6cm2), the receiving signal is reduced. The diameter of the particle is calculated from the amplitude of the reduction. Moreover, the fall speed of the particle is determined from the duration of the reduced signal (fig. 2).

Fig. 2 Explanation of the measuring principle

The measured values are measured by a signal processor (DSP). Calculation comprises the intensity, quantity and type of precipitation (drizzle, rain, snow, soft hail, hail as well as mixed precipitation), and the particle spectrum.

The type of precipitation is determined from the statistic proportion of all particles referring to diameter, and velocity. These proportions have been tested scientifically [2]. In addition, temperature is included in order to improve the identification:

precipitation with a temperature above 9˚C is automatically accepted as liquid precipitation (exception: soft hail, hail), and with a temperature of below -4˚C as solid. In the temperature range between, all forms of precipitation might occur.

2.1.1 Serial Communication

An RS 485 interface (4-wire or 2-wire mode) with several baud rates is used for the serial communication.

The communication can be carried out, for example, by means of a standard terminal program and a PC.

The RS 485 interface can operate in two different modes:

- 4-wire / full-duplex mode (factory setting):

The receive lines in the sensor are terminated with a resistance of 560Ω when a so-called jumper is directly above the contacts “T-” and “T+” on the 2-pole connecting-pin-line.

- 2-wire / half-duplex mode:

The transceiver lines in the sensor are terminated with a resistance of 560Ω when a so-called jumper is directly above the contacts “T-” and “T+” on the 2-pole connecting-pin-line. Latency: 20ms.

A special RS 485 – RS 232 adaptor is needed for communication with the PC.

2.1.2 General Telegram Format

The Precipitation Monitor sends telegrams to the PC. An example of such a telegram is in figure 3. The telegrams are in .txt format, one file for each hour. The filenames are according to the date and hour. One telegram is sent every minute, and each telegram contains data organized in columns.

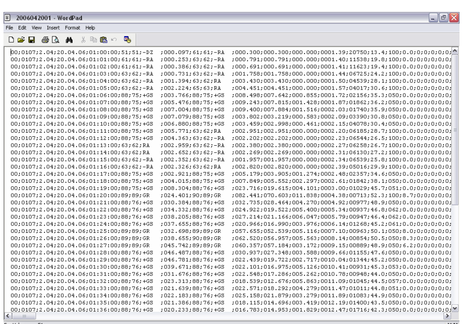

Fig. 3 The Telegram format

A fixed telegram format is used for the serial communication. The general format for a command:

- Data request: “<id>BB<CR>”
- Change of parameters: “<id>BBppppp<CR>”

id: device address number (00…99, initial value 00);

BB: two-digit command code (case-sensitive);

ppppp: a new parameter is set by entering a 5-digit value. The parameter is right-aligned, and must be completed with zeros from the left;

CR: Carriage Return (enter key).

The reply from the sensor is marked by an exclamation mark at the beginning of the return. The sensor sends an error message if the command is unknown, if the parameter is out of the allowed range, or if the command is in incorrect mode.

The necessary capacity of hard disk memory for recording data is approx. 100 MB data memory per month.

2.1.3 Commands

The main commands used for programming the precipitation monitor are presented in the table 2.

Table 2

Type	Commands
Communication	KY, BD, ID
Reset / version	RS
Data telegrams	TM, TR
Time / date	ZH, ZM, ZS, ZD, ZN, ZY, ZT
Diagnostics	FM, RF, ZB
Calibration	AT, AU, AV, AZ
Quantity measurements	RA, PT

The telegram is transmitted every minute by the instrument (without request of receiver) when the parameter “TM” is 4 or 5 (automatic mode).

The request of the telegram (polling mode) is possible with the command “TR”.

In the following paragraphs we will present only some of the commands.

- **KY**: set/get command mode

<id>KY<para5>

Two modes: normal mode (no setting of parameters available)

configuration mode (all commands allowed)

Value range: 0, 1 (0 – user; 1 – config).

Initial value: 0 (set to zero by power up, no storing).

- **BD**: set/get duplex

<id>BD<para5>

Setting for the using of a so-called 4-wire (RS422) or 2-wire communication (RS485).

Value range: 0, 1 (0 – full; 1 – half).

Initial value: 0 (full-duplex).

2.1.4 Communication with the PC

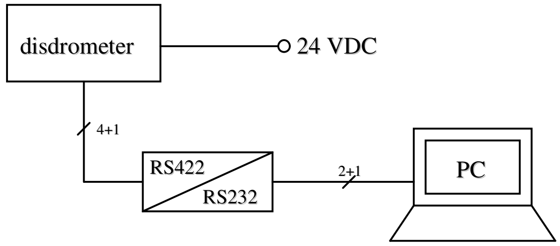

Fig. 5 Communication with the PC

To properly analyze the data, it would be preferable to have it organized in a table format, for ex. Microsoft Excel. There is no possibility to directly import in Excel the rain drop diameters and speeds, because Excel (and Access) allows only 256 columns, while the .txt data contains at least 440+3 columns of interest.
On the other hand, out of the 440 columns, one can derive 22 values for diameters, and 20 values for speeds; along with other information of interest, these values may be computed in VB (Visual Basic) and written in an Access data base.

2.2. PC Program LMNView
The LMNView program (which was provided with the disdrometer) is used to display data generated by the Thies Laser Precipitation Monitor. The program can not only achieve the data transmitted from the LMN but also present it in graphics display. The user-friendly design of the operating interface means that it is very simple to analyze all data records transmitted by the LMN.
The program has client-server architecture; it can display the spectrum of precipitation in 22 size ranges, and 20 speed ranges.
Data can be exported in Microsoft Excel, and can be displayed in calendar or tree format view.
The program is based on Microsoft Windows and will function with Windows 98 or higher.
The LMN-units sends a data record every minute.
LMN-Server relocates a date-time stamp to each data record, and saves the values as text files, as well as in binary form. Data records without valid measuring value are marked by "999999".

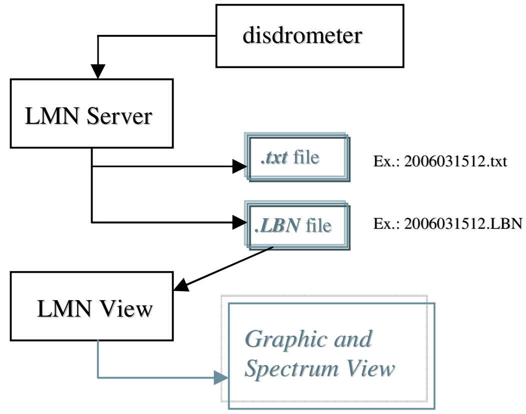

Fig. 7 Diagram of the LMNView Program

On a closer analysis of the LMNView Program, we noticed the following:
A few files, called the Demo Data files were opened at first, and we noticed that these files have discrepancies concerning the date/time in the filenames, and the date/time contained inside the files.
The real-time clock of the disdrometer needs to be synchronized every time it is turned on, because every time it is turned on, the Disdrometer's clock starts at 00:00, January 1st 2005.
Sending direct commands to the Laser Precipitation Monitor doesn't work from the LMN View Program. If we use the Hyper Terminal program in Windows XP, sending commands to the Disdrometer works.
The LMN View Program is Meteo-oriented; there is no possibility to export rain drop diameters or speed data directly from the LMN View Program.
The LMN View Program is resource consuming.

3 Processing Data From The Precipitation Monitor
Because of the disadvantages above, and because we need access to more data than provided by the LMNView program and its graphics, we constructed an application in Visual Basic, in order to program and communicate with the Precipitation Monitor.
The LMNView program doesn't offer the possibility of exporting into a Microsoft Excel table the data concerning the rain drop diameters, or the speeds of each class of rain drops. This information is present in the .txt files provided by the Laser Precipitation Monitor. To have access to this information, and have the possibility to construct other graphs than the ones offered by LMNView, the application in Visual Basic was elaborated. Such graphs can be concerning the drop size distributions, number of drops with each class of speeds, etc.

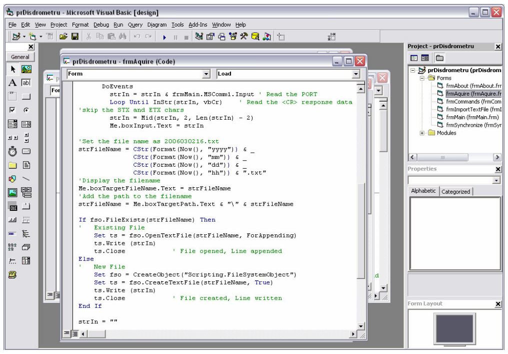

Fig. 11 The Program in Visual Basic

The application in Visual Basic, which we called DisdroCentre.exe, consists of several forms, developed under one project. In the following paragraphs, we will present each form and its characteristics.

3.1 Main

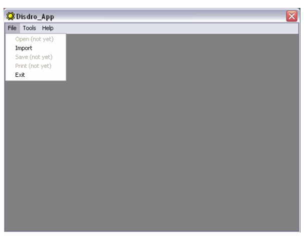

Fig. 12 Main window

This is the main window of the program, which launches the commands needed to control the disdrometer and acquire data from it. They can be accessed by accessing the menus File, Tools, Help.

3.2 About

Fig. 13 "about" window

The About Frame is shown in the figure above.

3.3 Synchronize

Every time the Precipitation Monitor is turned on, the internal clock starts from 00:00, January 1st 2005; therefore, the first thing that had to be done was the synchronization of the internal clock. Using the KY command, combined with the time/date commands, the synchronize form synchronizes the Laser Precipitation Monitor as shown in fig. 14.

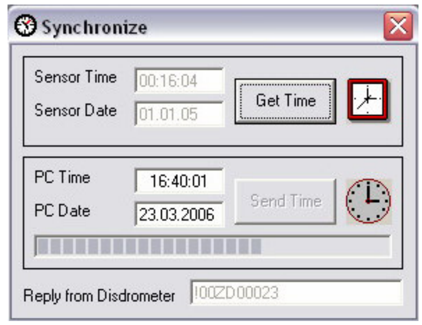

Fig. 14 Synchronization of the internal clock

This part of the program first acquires the date and time from the computer and displays it in the PC time and date boxes.

When the button Get Time is pressed, the program checks if the communications port is open, and in case it is, returns an error saying: "Port in use". If not, it opens the port and receives via the serial port the date and time of the sensor.

In order to send the correct time and date to the sensor, the Disdrometer's serial (ID) on the RS485 bus is "00". Pressing the Send time button starts the synchronization. The reply message from the disdrometer is also displayed.

3.4 Acquire

The next step is acquiring the data from the Precipitation Monitor. In order to do this, the application DisdroCentre.exe allows the user to specify a target directory for the .txt files, as well as displays the filename which the data is currently being sent to, and the current message from the Precipitation Monitor. The default target directory is set to C:\Projects\VB\Disdrometru\Txt_Out\ .

To start the acquisition mode, the user has to press the Acquire button, as seen in Fig. 15.

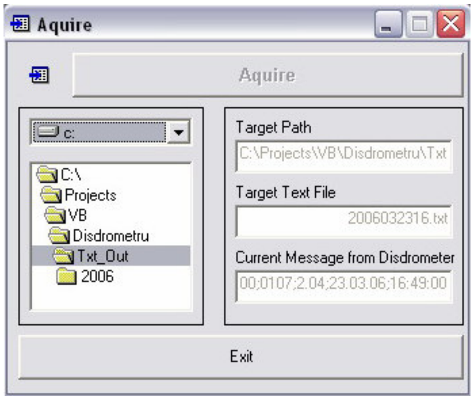

Fig. 15 Acquiring data from the Precipitation Monitor.

3.5 Import

After the .txt files have been written, they have to be imported into an Access database. Another part of the DisdroCentre program handles this, as shown in Fig. 15. The user will then choose one file and the database file and then click on Import. The program was created to write only new data in the table; therefore, if the user is trying to import data that already exists, the program will respond „x lines read and 0 lines written".

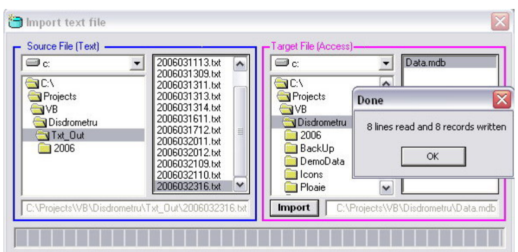

Fig. 16 Importing data from .txt files

The default directory for the .txt files is C:\Projects\VB\Disdrometru\Txt_Out\ and for the Microsoft Access DataBase C:\Projects\VB\Disdrometru\ . Importing a .txt file selects the data from the .txt file and copies it into a table.

After importing the data from the .txt files, the user opens the Data.mdb file in Microsoft Access. The starting time and ending time for displaying the graphs can be chosen as shown in Fig. 18.

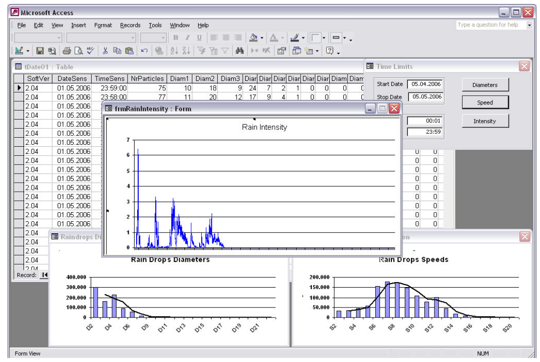

Fig. 18 Choosing time limits in MS Access

The graphs corresponding to the rain intensity, distribution of rain drop diameters and speeds are constructed according to the time interval defined in the previous step.

At a closer look at the data imported from the raw .txt files, we noticed that there are some discrepancies between the total number of particles detected by the disdrometer, and the sum of all the columns of numbers of particles.

Measurements of real rainfall were made, and using the application we developed, results were obtained. These results are summarized in the graphs presented in the figures, below:

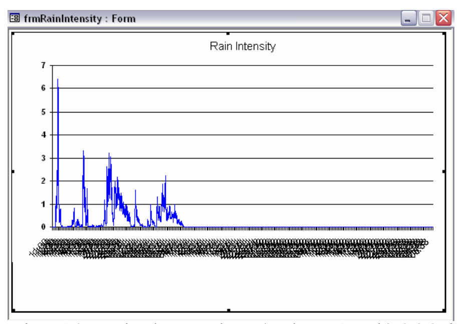

Fig. 12 Rain intensity during April 2006

Figure 12 shows the total rainfall during the month of April 2006, and in figure 13 the intensity, rain drop diameters and speed corresponding to each rain drop size class for April 06.

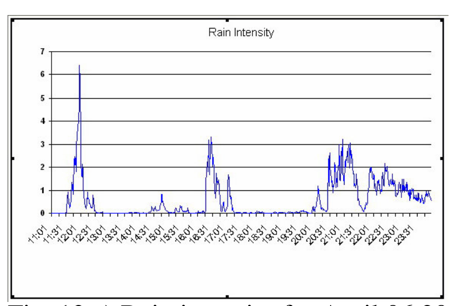

Fig. 13 a) Rain intensity for April 06 2006

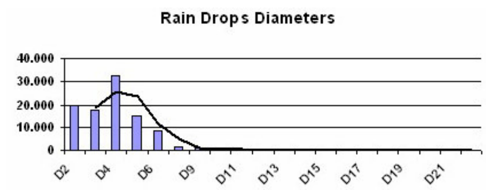

Fig. 12 b) Rain drops diameters distribution for April 06 2006

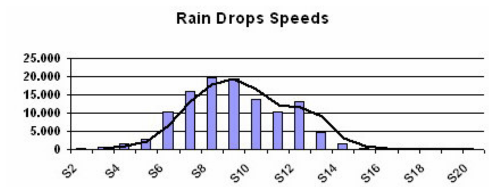

Fig. 13 c) Rain drops speeds distribution April 06 2006

Figures 14 a, b and c show the rainfall intensity, rain drop diameters and speed corresponding to each rain drop size class for April 20.

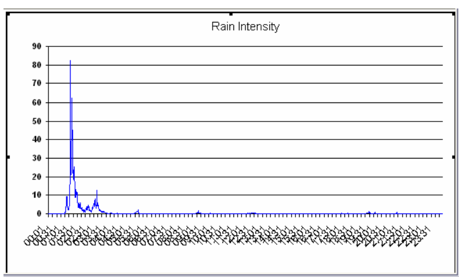

Fig. 14 a) Rain intensity for April 20 2006

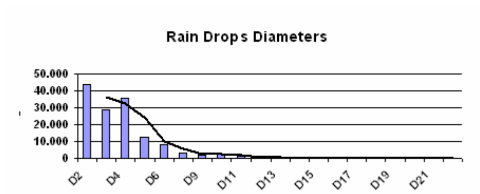

Fig. 14 b) Rain drops diameters distribution for April 20 2006

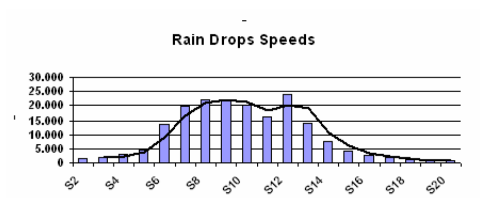

Fig. 14 c) Rain drops speeds distribution April 20 2006

4 Conclusions

The objective of this paper was to present a solution for computing and showing results of rainfall measurement. The paper is part of an extensive study, which includes measuring the characteristics of rainfall, and the generation of rain, by means of a rain generator. The measurement equipment used is a Disdrometer, built by Thies Clima.

This paper analyzes the limitations and disadvantages of the disdrometer as well as the program provided with this equipment which is available for purchase on a medium scale. We propose a solution to eliminate these disadvantages and limitations.

In the final part of the paper, there are some examples which validate the raw data transmitted by the disdrometer.

After taking a closer look at the data imported from the raw .txt files, we noticed that there are some discrepancies between the total number of particles detected by the disdrometer, and the sum of all the columns of numbers of particles. These two numbers were different in some cases. This might be because the disdrometer can only detect one single particle at one moment in time, which can lead to errors if the rain is very heavy.

An aspect which deserves further study is the diameter of particles, and their shape according to their size, and if this influences in any way the diameter showed by the measuring equipment.

Another future study will be designing a parallel method of measuring the intensity.

Acknowledgements:

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References:

[1] Thies Clima, Laser Precipitation Monitor, *International Journal of Science and Technology*, 5.4110.xx.x00 v2.0x STD

[2] Gunn, R. and Kinzer, G.D, *The Terminal Velocity of Fall for Water Droplets in Stagnant Air*, vol. 6, 1949.