LSI LASTEM S.r.l.
Via Ex S.P. 161 Dosso, n.9 - 20090 Settala Premenugo (MI) - Italia

Tel.: (+39) 02 95 41 41
Fax: (+39) 02 95 77 05 94
e-mail: info@lsi-lastem.it
WEB: http://www.lsi-lastem.it
CF./P. Iva: (VAT) IT-04407090150
REA: 1009921 **Reg.Imprese:** 04407090150

LSI LASTEM method for thermal transmittance U (or K factor) measure

User Manual

Updating 23/01/2009

Cod. INSTUM_00459_en

Index

1.Presentation of the product

The *thermal transmittance U* (previously called *K factor*) is defined (UNI EN ISO 6946) the thermal flow that passes through a unit area (thermal flow density *q*) in the presence of difference of 1 Kelvin degree temperature between *Ti* indoor and *Te* outdoor (considering stable conditions):

$$U = \frac{q}{T_i - T_e}$$

The measure of *U transmittance* enables to know the characteristics of thermal conduction of the buildings' walls; it's needed for calculation of thermal requirements for buildings heating and energy saving. Actually *U* transmittance value shows the thermal insulating capacity of the walls and it can be used to value the energy performances of the buildings. The calculation of transmittance is needed for energy certification of the buildings according to EU directive 2002/91/ CE about energy efficiency of the buildings; it has been acknowledged by Italy under D.Lgs. 192/05 and further modifications and integrations under D.Lgs 311/06.

LSI LASTEM method of measure allows the measure and the calculation of the *U* thermal transmittance of industrial or residential buildings' walls using following measure equipments:

- N. 1 Heat flux sensor ;
- N. 3 or 4 temperature probes for wall's surfaces. I.e. use 2 surface temperature probes indoor and 2 outdoor, and consider the average of two surveys for data analysis, in order to minimize the effect of possible small lacks of homogeneity of the wall. It's also possible use only one temperature probe (instead of two probes) in inner wall, because it's limited variability.
- Datalogger or PC;
- Processing program.

1.1.Measure using BabucA/M type instruments

To carry out the measure under way of *U* thermal transmittance of the walls using Babuc A/M datalogger, it needed connect following probes to Babuc:

- 1 heat flux sensor for walls *BSR240*;
- 3 or 4 surface temperature probes used for walls *BST124*.

Two surface temperature probes have to be placed on the outside of the wall and one (or two) probe on the inside of the wall together with the heat flux sensor.

At the end of the measures it's possible to export the data by means of Infogap program and then process them by BSZ310-InfoFLUX program for calculation of thermal conductance using "progressive means" or "Black- box" methods.

For more information about *BST124* e *BSR240* probes, make reference to technical chart MW8501.

Standard Kit

		Sensors needed for calculation of conductance by InfoFLUX program
1	BSR240	Heath flux sensor
3	BST124	Contact temperature probes Pt100, cable L. 10 m (with Babuc A it's possible use 4 probes BST124)
		Data logger
1	BSA020	BabucM
	BSA010	BabucA (instead of BabucM)
1	BSC010	Feeder 220 Vac
1	BSH100	Serial cable
		Software
1	BSZ302	*InfoGAP* or *InfoGAP K Edition* Program
1	BSZ310	*InfoFLUX* Program for calculation of thermal conductance

1.2. Multi-point measure with cordless sensors and datalogger

LSI LASTEM has got multi-point wireless measure systems that allow the measure and the calculation of U thermal transmittance of industrial or residential buildings' walls using following instruments:

- One heath flux sensor for walls *BSR240*;
- One (or two) surface temperature probe *BST124* for inside wall (Tis);
- Two surface temperature probe B*ST124* for outside wall (Tes);
- One or more cordless transmitter *DME809* which connect the above mentioned sensors; it transfers messages to computer for calculation of transmittance;
- Possible radio signal repeaters *DEC401/2*;
- One *DEC301* radio receiver for reception of measures transferred by *DME809* sensors and their submit to processing system;
- One processing system consisting of one *BabucABC* datalogger or *E-Log* and one PC where have been installed *InfoGAP* (*K Edition*) and *InfoFLUX* programs for calculation of transmittance, or instead of the datalogger, the same PC with *SCRicIG* program operative (see §1.3). In this case PC's used for storage of data acquired by the sensors and it must be switched on during whole survey time.
- *E-Log* or *BabucABC* datalogger may be also connected to sensors through cable (DPE240 heath flux probe and DLE124 surface temperature probes).

Standard Kit

		N measure points, each point consists of:
1	DME809	Cordless transmitter (signal radio transmission)
1	DEC252	Aerial
1	BSR240	Heath flux sensor
3	BST124	Contact temperature probes Pt100, cable L. 10 m
		Cordless receiver
1	DEC301	Cordless sensors receiver
1	DEC252	Aerial
1	DWA601	Receiver connection cable --*E-Log / BabucABC*
		Data logger E-Log
1	ELO310	Data logger *E-Log,* bench type
1	DEA260	Feeder for *E-Log*
		Data logger *Babuc ABC* (instead of *E-Log*)
1	DGB107	Data logger *BabucABC,* in portable case
1	DEA260	Feeder for *BabucABC*
1	DEB515	Serial cable
		Programs
1	BSZ302	*InfoGAP K Edition* Program for acquired data management
1	BSZ310	*InfoFLUX* Program calculation of wall's conductance
		Optional:
		Measure-point with sensors connected directly to datalogger through cable
3	DLE124	Contact temperature probes, cable L. 10 m
1	DPE240	Heath flux probe, cable L. 5 m

1.3.Use of PC by radio connected to sensors (without data logger)

This method uses PC, instead of datalogger, to receive the measures by radio from DME809 units and store them by means of *SCRicIG* (BSZ330) and InfoGAP (BSZ302) programs; this PC must be switched on during whole survey time.
The stored measures may be managed later by means of BSZ310-InfoFLUX program for calculation of transmittance.

Standard Kit

		N measure points, each point consists of:
1	DME809	Cordless transmitter (signal radio transmission)
1	DEC252	Aerial
1	BSR240	Heath flux sensor
3	BST124	Contact temperature probes Pt100, cable L. 10 m
		Cordless receiver
1	DEC301	Cordless sensors receiver
1	DEC252	Aerial
1	DWA601	PC-receiver serial cable
1	BSC012	Feeder for receiver DEC301
		Software
1	BSZ330	Scric-IG program for storage of data from DME809 sensors into InfoGAP data base
1	BSZ302	*InfoGAP K Edition* Program for acquired data management
1	BSZ310	*InfoFLUX* Program for calculation of thermal conductance

2.Technical Characteristics

BSR240 (or DPE240) Sensor

Range	-50 ÷ 50 W/m^2 (when connected to Babuc or E-Log)
Sensitive element	Thermopile
Operative Temperature	-30 ÷ 70 °C
Diameter	80 mm
Thickness	5 mm
Sensitivity (standard) exact value on calibration certificate	0.050 mV/W*m^2
Resistance (nominal)	2 Ω
Response time	4 min
Dependence on temperature	< 0.1 %/°C

BST124 Sensor:

Range	-50 ÷ 80 °C
Sensitive element	Pt100 DIN-A
Mechanics	Phosphorous Bronze flat probe
Response time (T90*)	10 s
Precision	See tab. *Precision Pt100*
Cable	PVC flat (-15 ÷ 75 °C)

T90*: measured from air to surface with conductive paste

Precision Pt100 DIN-IEC751:

Temperature (°C)	**DIN-A (±°C)**
-100	0,35
0	0,15
20	0,19
40	0,23
100	0,35

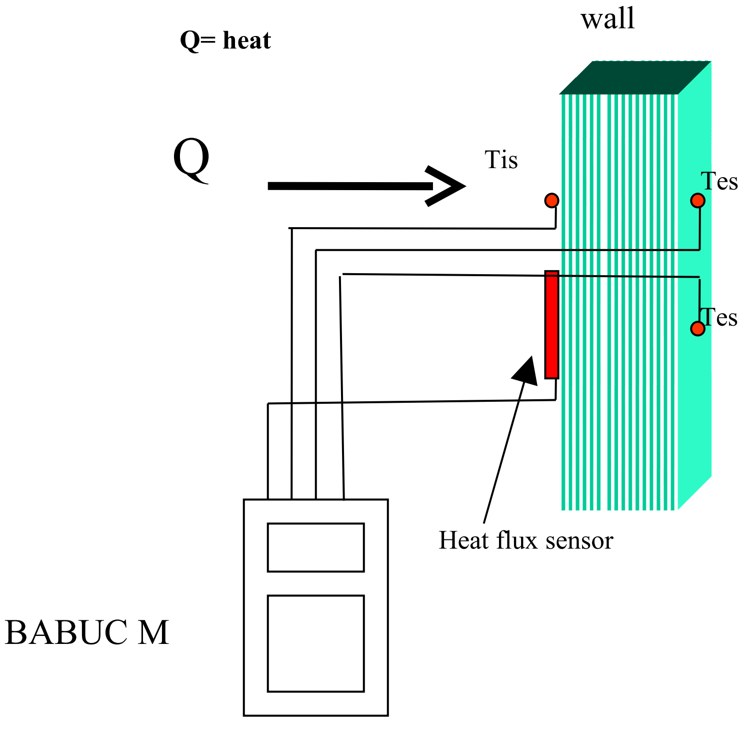
DME809 cordless transmitter:

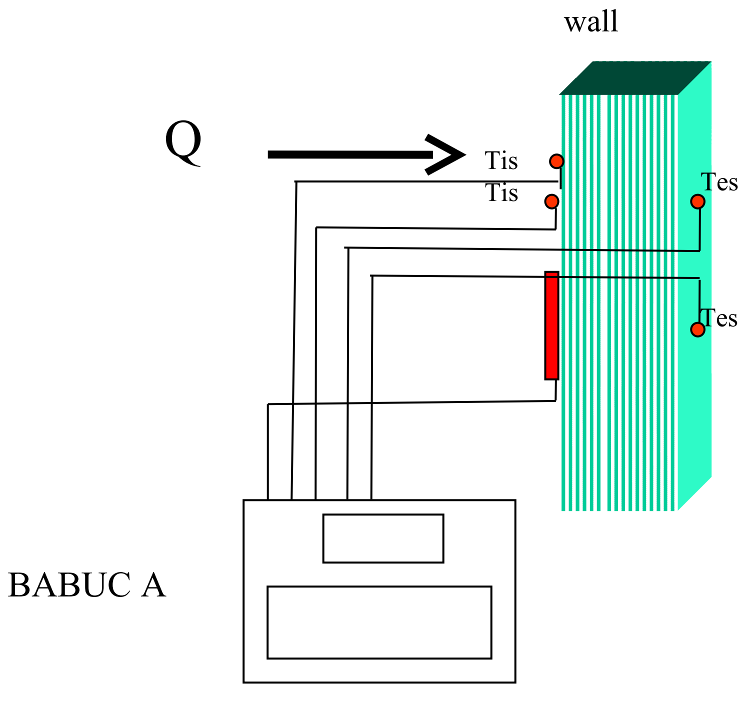
***Outside temperatures* Section**	
Range	-30 ÷ 70 °C
Input 2, 3, 4 with 3 wires connection	Pt100
Precision	0.1 %
Resolution	0.025 °C
***Flow* Section**	
Range	-50 ÷ 50 W/m^2
Input 1	-3.5 ÷ 3.5 mV
Precision	1.75 µV
Resolution	0.1 W/m^2

3.Connection diagrams

3.1.Connection for BabucA/M

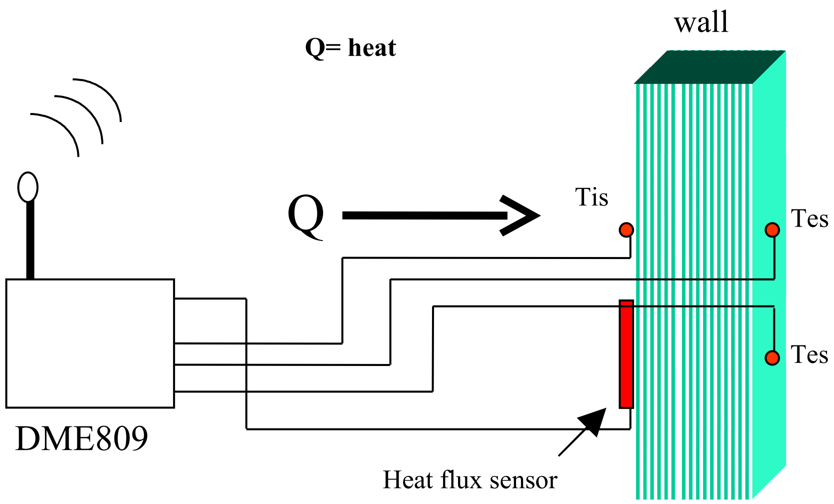
Connect the probes to BABUC datalogger through their "minidin" connector, like shown in the picture.



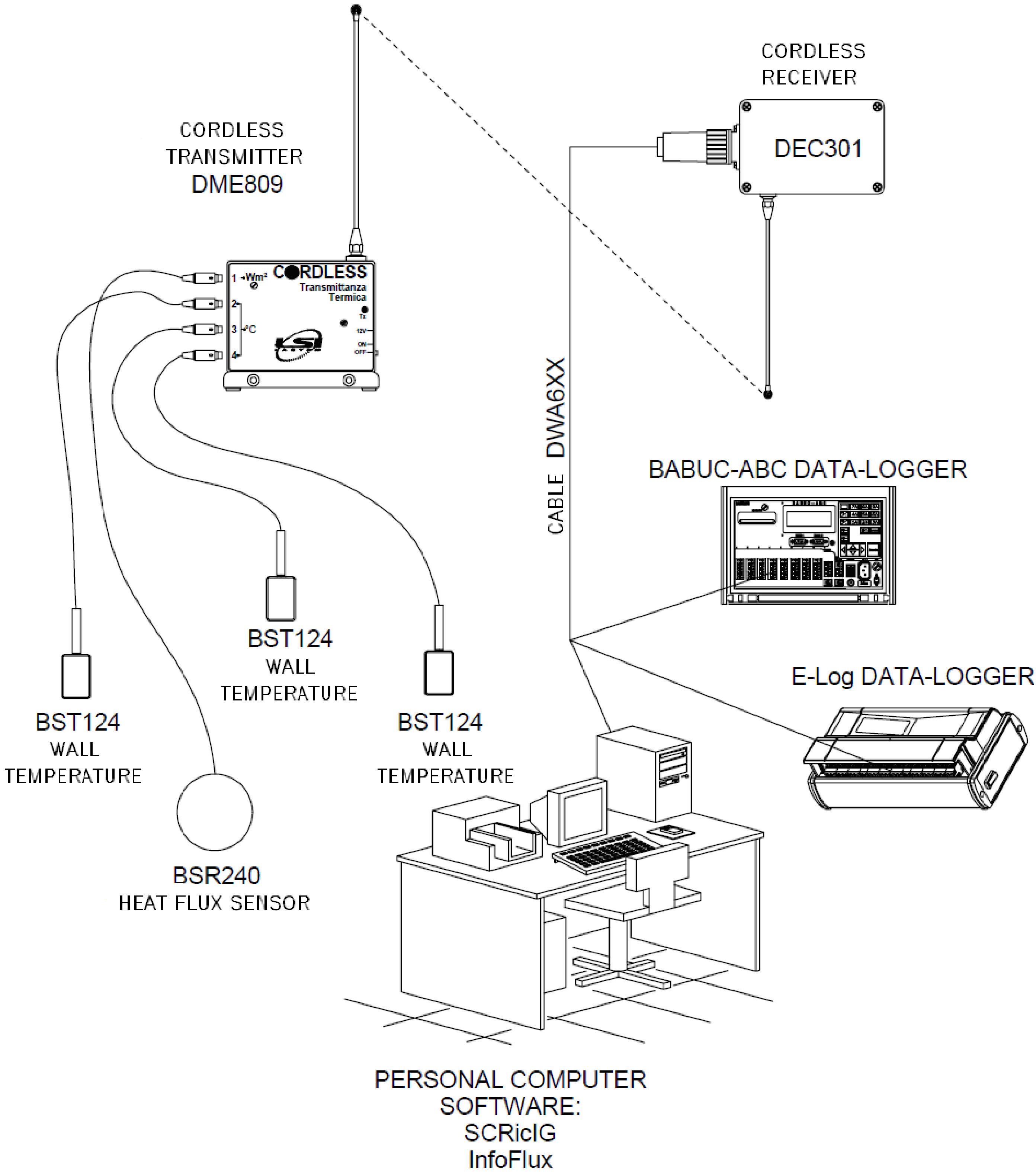


3.2. Connection diagram for DME809 cordless sensor

Connect the probes to DME809 transmitter through their “minidin” connector, like shown in the picture.



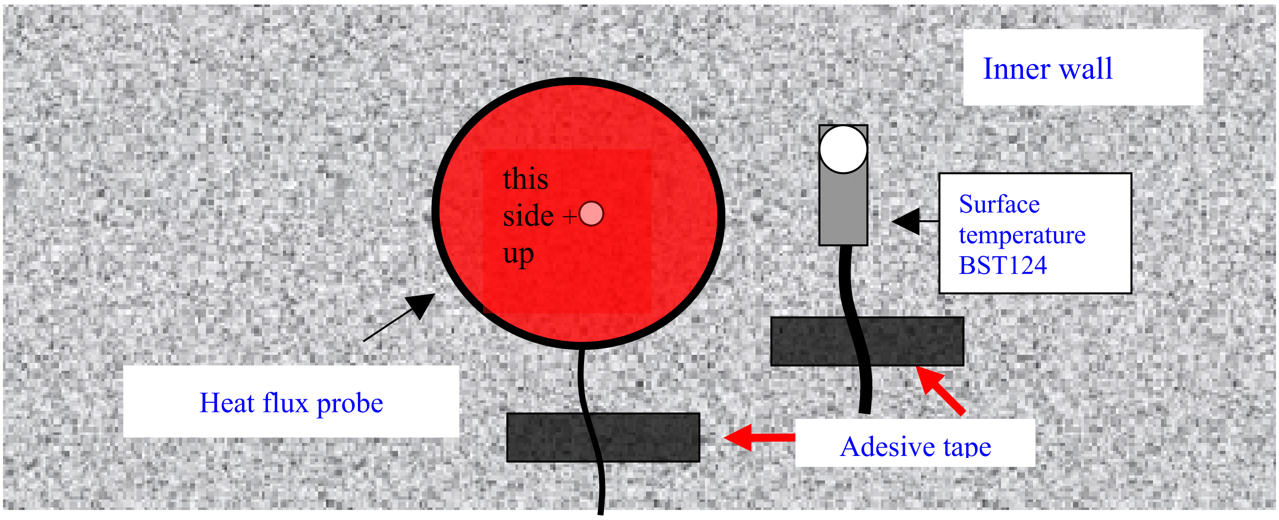
DME809 transmitter sends the acquired data to PC or to BabucABC and E-Log dataloggers by means of DME301 radio transmitter. You can find further information about characteristics of LSI LASTEM “ Cordless ” radio equipment in relevant user manual (cod. MW6095).


CORDLESS
TRANSMITTER
DME809
CORDLESS
Transmittanza
Termica
CORDLESS
RECEIVER
DEC301
CABLE DWA6XX
BABUC-ABC DATA-LOGGER
E-Log DATA-LOGGER
BST124
WALL
TEMPERATURE
BST124
WALL
TEMPERATURE
BST124
WALL
TEMPERATURE
BSR240
HEAT FLUX SENSOR
PERSONAL COMPUTER
SOFTWARE:
SCRicIG
InfoFlux

4.Measure method

Place on the outside of the wall n. 2 surface temperature probes (BST124) and the heat flux sensor and n. 1 or 2 surface temperature probes (BST124) on inside of the wall.
Prepare the instruments like explained below:

1) Place the heat flux sensor on the inner wall, in representative part of the wall and far from direct heat sources. It's a good rule place the heat flux sensor on inner side of the wall in order to minimize the trouble effects of sun radiation. Place the blue face of the sensor on the wall and the red face, with positive side (+), will be like shown in the picture. Actually thermal flow passes through the wall (in winter conditions) from inside to outside.



Place the probe on the wall interposing BF42 (cod. MM7500) conductive paste between the sensor and the wall in order to improve the heat conduction. The probe's cable may be fixed to the wall using two or three adhesive tape points. As the conductive paste is very fat, it cannot be used on delicate surfaces. If you cannot use the thermal paste, you have to make attention to obtain good thermal transmittance of the probe on the wall anyway, in order to avoid measure error (that it's approx some percentage value). It's possible put adhesive tape (paper scotch preferred) on the heat flux sensor's edge making attention to not cover the sensitive element in the probe's centre.

The sensor measures the thermal flow only by its positioning point; for this reason it's of primary importance place it in representative part of the "flowing wall". In order to avoid border results do not place the probe in the areas near the corners or in the areas with physical or geometric anomalies (pillars, bearing walls, conduits, insulating interruption, thermal bridges). It' right at the beginning make an inspection and examine the building's plan (if available). It's recommended the respect's distance of 60 – 70 cm from every discontinuities. Furthermore it's necessary to carry out the initial screening of the wall's temperatures (by means of contact or infrared or thermal camera surface temperature probes) in order to place the sensor in homogenous part of the wall (that has limited spatial variations of temperature) and avoid thermal-bridges.

2) Place (near the heat flux sensor) n. 1 or 2 contact temperature surface probes in the inner side of the wall and n. 2 contact temperature surface probes in the external side of the wall. Make attention that all sensors have to adhere with the wall perfectly; when possible use the heat conductive paste in order to avoid the contact thermal resistance, and fix BST124 and the cable with adhesive tape (paper scotch preferred). The material used for fixing of the sensors must have same radiative characteristics of the walls' surfaces.

Avoid that the sunbeams hit directly the sensors on the outside wall; the different optical phenomenon might cause measure errors. For this reason it's recommended the positioning of the sensors on wall facing north or north-east (if possible); place BST124 on shaded wall and cover BST124 with materials have the same optical characteristics like the wall.

3) The transmittance measure needs some time: from some hours to several days, and particular conditions.

Make the testing during season with high temperature differences between indoor and outdoor (approx 8° - 10° C difference between indoor and outdoor) in order to obtain high flow values and low sensitivity to external inconveniences. Stationary surrounding conditions are needed to can use the method of progressive means. For example: the heating system could be switched-on during the measure in winter in order to obtain this favourable condition .

Standard sampling times for measure of thermal transmittance: 15 minutes; the survey lasts from 3 to 7 days or more, depending on the wall's type and temperature conditions. We recommend to download data on PC and check the measure's output before the survey stop.

5. Babuc A/M Programming

Set-up the value of calibration's factor of BSR240 heat flux sensor into BABUC; you can find it in calibration certificate of the sensor (some times you can find it on the cable). Input the calibration factor in the option *"SYSTEM – K FACTOR"* ; its value mV expressed. In case the calibration value is µV expressed, divide it by 1000 before its input into Babuc.
Start a *Standard survey* with sensors' acquisition time-gap of 15 minutes.

To use the instrument BABUC A/M make reference to its user manual..

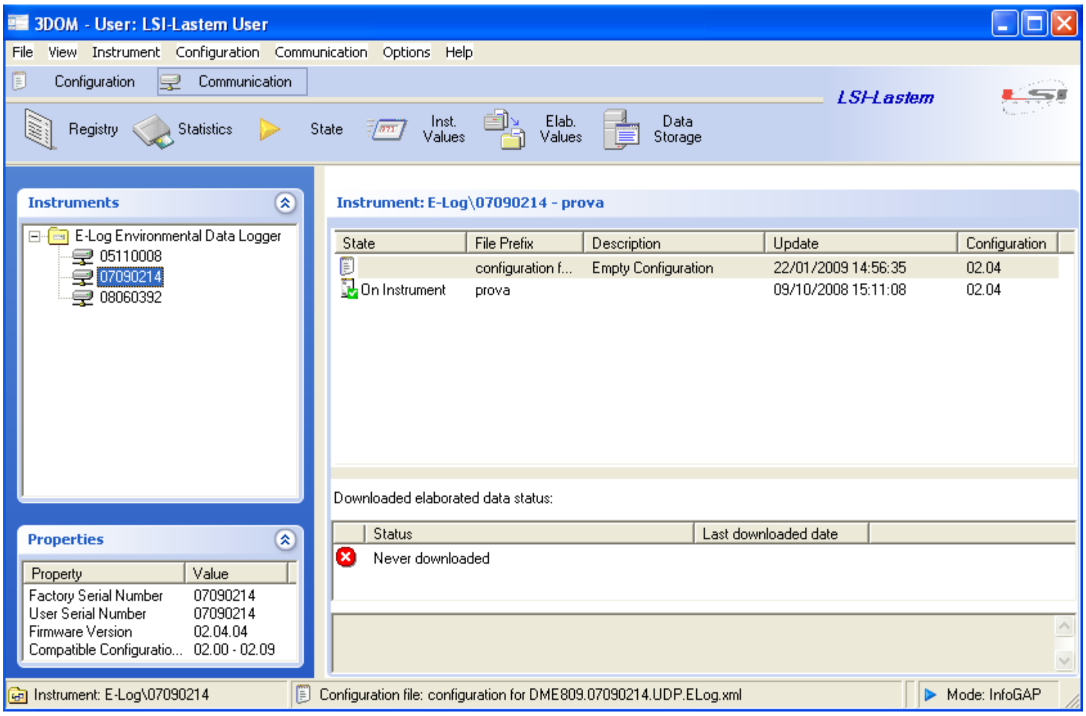
6.E-Log Configuration

If E-log datalogger is used like acquisition system it must be configured correctly by means of *3DOM* program in order to acquire the data from the cordless sensors. Make reference to: program's on-line guide about the details of configuration's transfer procedures, and user manuals of E-Log datalogger and cordless sensors range.

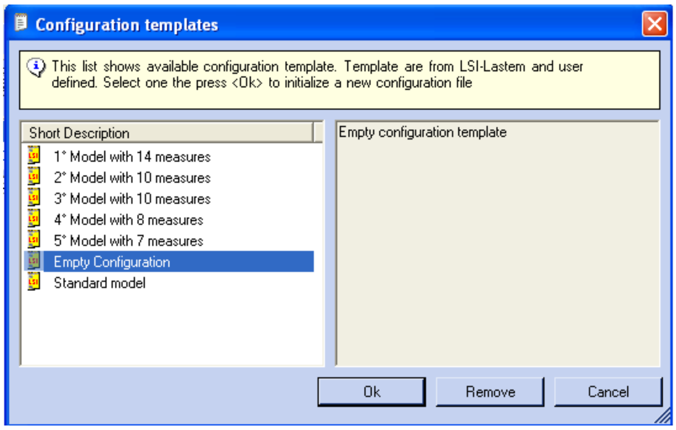
Here below you can find the instructions for correct configuration of E-Log instrument.

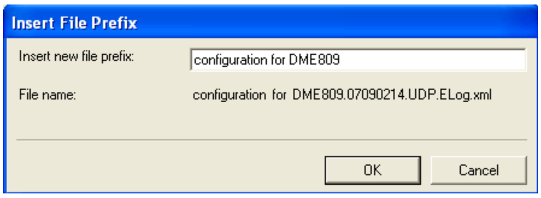
6.1.1.Change of the configuration

1. Start program 3DOM; Select the instrument that have to be configured; press *Configuration, New;*

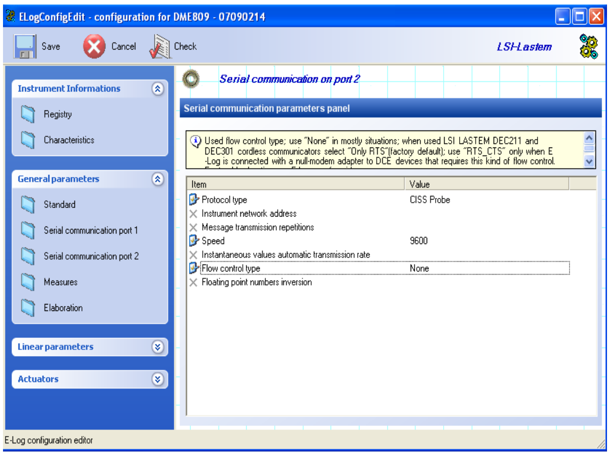


2. Select the empty configuration and press *Ok*; Input the code of the file (for example *Configuration for DME809*);

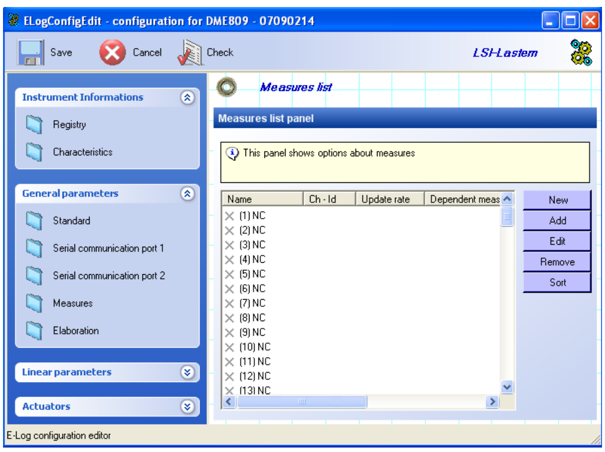


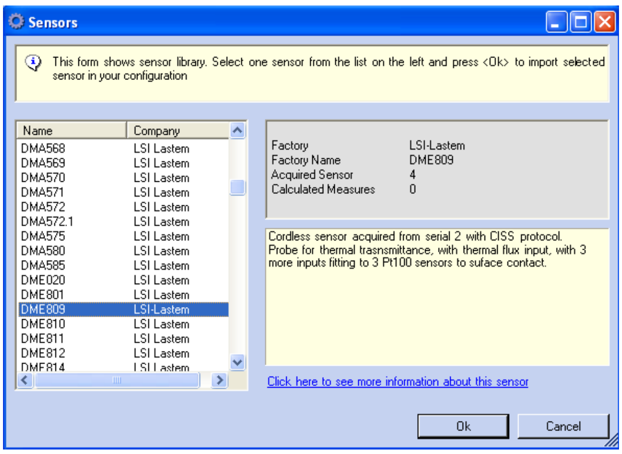


3. Select the only just set-up configuration (see mask at point 1); and press Edit; select *Serial Communication port 2* and set-up the parameters like shown in the mask below on the right (Protocol type: *CISS Probe*, Speed: *9600bps*);

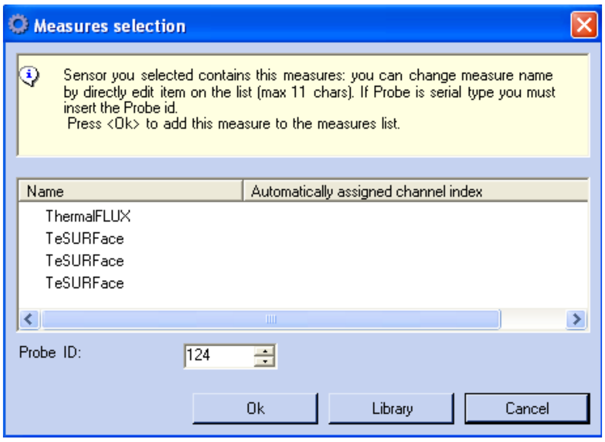


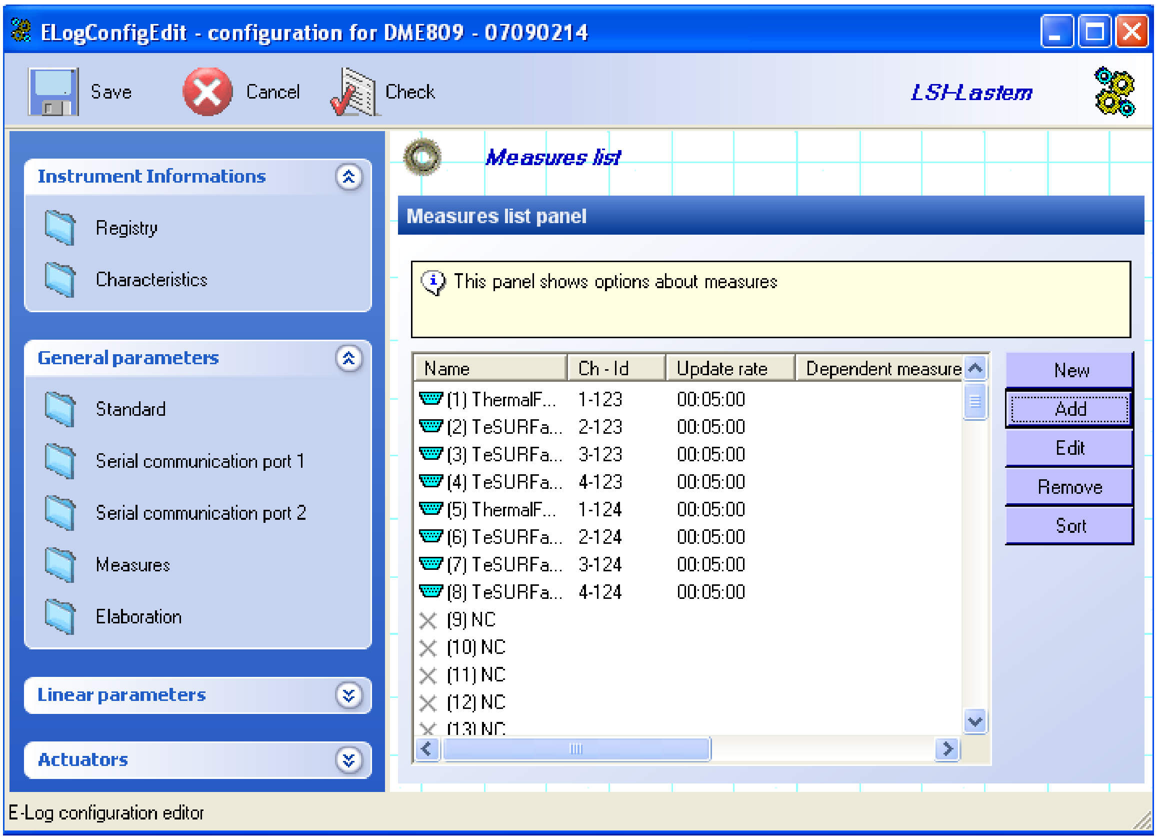
4. Select *Measures;* press *Add*, you'll see the mask of the sensors manufactured by LSI LASTEM, select the sensor DME809 and press *Ok*;





5. Set-up the *Probe ID*: it's usually last three numbers of the serial number written on the sensor's container (i.e.. 124 if serial number is 0709124); press *Ok*; repeat to configure all the sensors (max. 24 DME809); at the end press *Save*;





6.1.2. Transfer of the configuration

Send E-Log configuration following the instructions below:

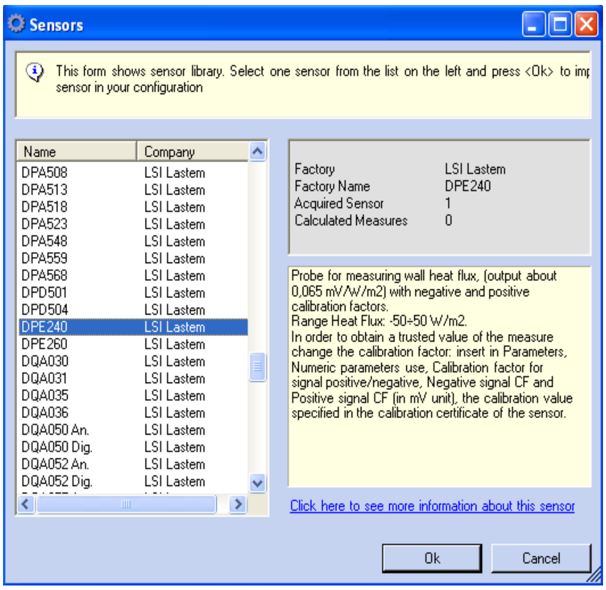
1. Connect serial cable to RS232 of PC to serial 1 of E-Log, and check the communication parameters;
2. Power E-Log instrument and switch-on it;

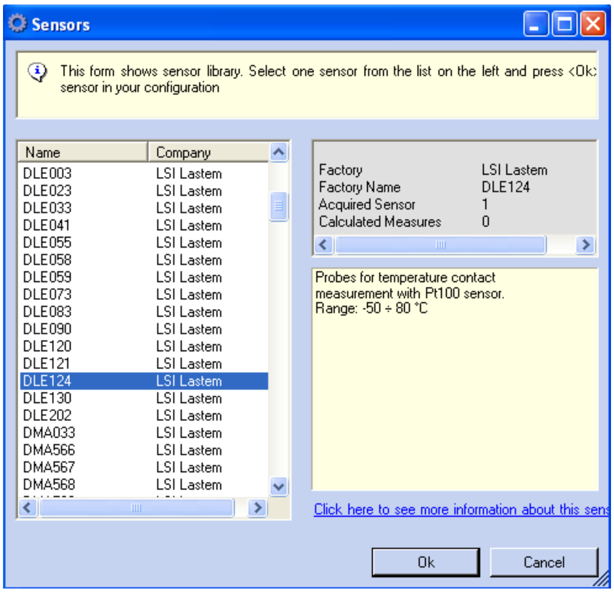
3. Select the only just set-up configuration from main mask and press *Configuration - Send*; await for the end of the transfer; caution: this operation cancels the previously processed data off the instrument; download the data before this operation start if you need them.
4. Now you can check the acquisition of the data: connect the DEC301 through suitable cable, power it, switch-on it, connect the flow and temperature probes to all DME809 sensors and switch-on them (see cordless system manual for different connection types);
5. At the end of the connections check the values acquired by the sensors and by the instrument on E-log display.

6.1.3.Configuration of the inputs from terminal board

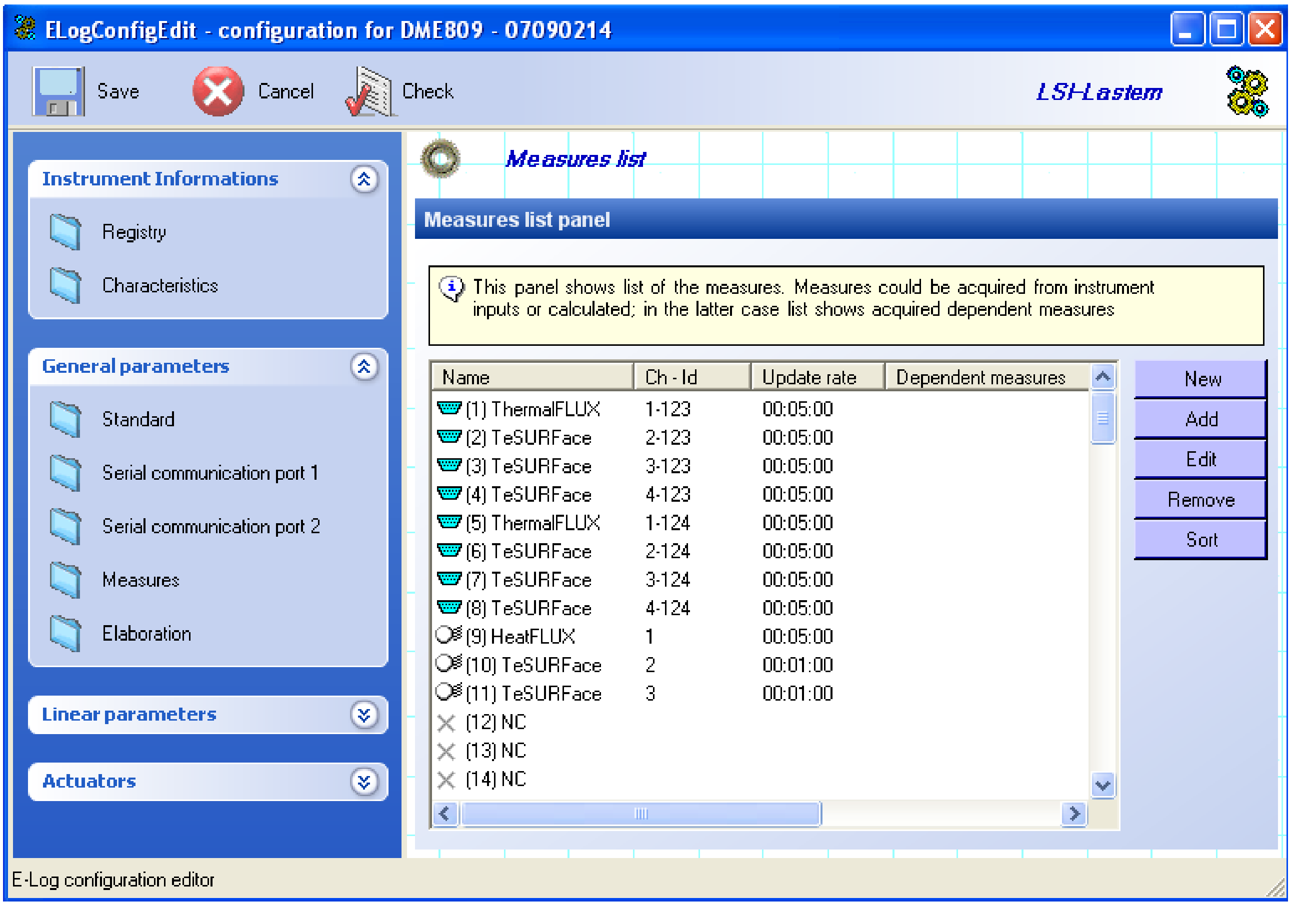
If E-Log is used to acquire DPE240 and DLE124 sensors connected to its terminal board (analogue type), modify the configuration like shown below:

1. From main mask of 3DOM select the configuration to modify, or set-up a new one; follow;
2. Press *Add* and select DPE240 flow sensor; follow the instructions of the mask and modify the calibration factor of the sensor that has to be connected to input 1 of the terminal board;
3. Press *Add* and select DLE124 temperature sensor that has to be connected to input 2 and press Ok; repeat it for inputs 3 and 4;
4. Repeat the points 2, 3 for further possible connected probes;





5. At the end of the configuration save the configuration and send it to E-Log;



6.1.4.Connection of the probes

Switch-off the instrument and connect the configured probes to suitable clamps, like shown in the table below:

TERMINAL BOARD								
Analogue Input	**Signal**				**GND**	**Actuator**		
	A	B	C	D		Number	+V	0 V
1	*1*	*2*	*3*	*4*	*7*	**1**	*5*	*6*
2	*8*	*9*	*10*	*11*				
3	*12*	*13*	*14*	*15*	*18*	**2**	*16*	*17*
4	*19*	*20*	*21*	*22*				
5	*34*	*35*	*36*	*37*	*40*	**3**	*38*	*39*
6	*41*	*42*	*43*	*44*				
7	*45*	*46*	*47*	*48*	*51*	**4**	*49*	*50*
8	*52*	*53*	*54*	*55*				

- Input 1: connect the white wire to B clamp and the green wire to C and D clamps of the DPE240 flow probe.
- Input 2: connect the wires 1-1 to A and B clamps and the wires 2-2 to C and D clamps of the DLE124 temperatures probe.
- Input 3: connect the wires 1-1 to A and B clamps and the wires 2-2 to C and D clamps of the DLE124 temperatures probe

- Input 4: connect the wires 1-1 to A and B clamps and the wires 2-2 to C and D clamps of the DLE124 temperatures probe.
- Input 5: connect the white wire to B clamp and the green wire to C and D clamps of the DPE240 flow probe.
- Input 6: connect the wires 1-1 to A and B clamps and the wires 2-2 to C and D clamps of the DLE124 temperatures probe..
- Input 7: connect the wires 1-1 to A and B clamps and the wires 2-2 to C and D clamps of the DLE124 temperatures probe..
- Input 8: connect the wires 1-1 to A and B clamps and the wires 2-2 to C and D clamps of the DLE124 temperatures probe..
- Switch-on E-Log and check the acquired data; for further information make reference to per E-Log user manual.

7.Programming of BabucABC

DME809 sensor must be enabled to operate with BabucABC or E-Log datalogger. As BabucABC is used like acquisition system, its configuration must be modified through *ABCSetup* form; this form is usually installed together with *InfoGAP* program.

Here below you can find the operations needed to modify BabucABC instrument correctly.

7.1.1.Configuration of the operation codes

In order to use the DME809 cordless sensors, these are the programmed operation codes most suitable to characteristics of the acquired quantities:

091 – Temperature
092 – TeSURFACE

These operation codes may be used by all cordless sensors having the same acquisition time-gap (5 min.); if needed different acquisition time-gaps or different texts, you have to select further operation codes and re-program them accordingly; here below you can see the codes that can be better modified through *Setup* program:

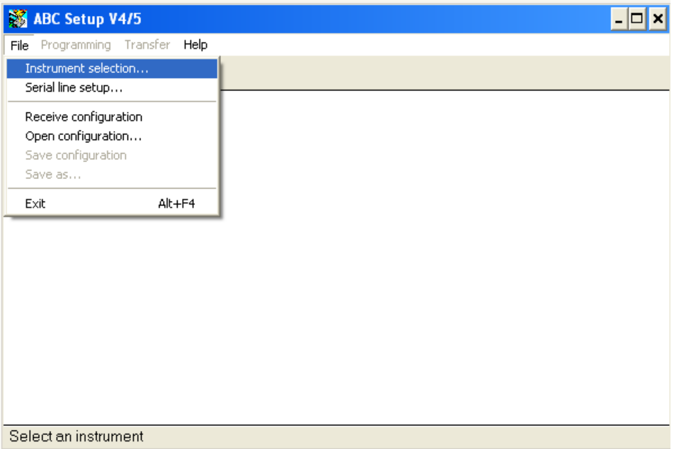
011 – Temperature
013 – TeSURFACE
014 – Temperature
021 – Temperature
022 – TeSURFACE
023 – Temperature
024 – TeSURFACE
025 – Temperature
026 – TeSURFACE
027 – Temperature
028 – TeSURFACE
029 – Temperature
030 – TeSURFACE.
061 – FLUX Thermal

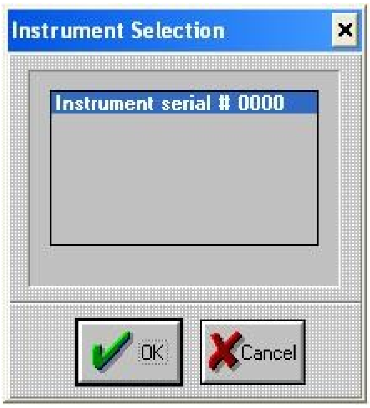
Note: the operation codes used for cordless sensors cannot be used by sensors with analogue or digital output at the same time.

Program new operation codes following these instructions:

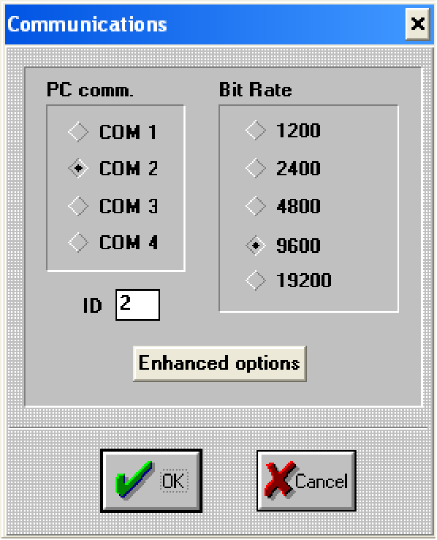
1. Check that *ABCSetup* form (included into *InfoGAP* program from *LSI LASTEM Products CD)* has been installed on PC;
2. From menu *Program* of Windows select and start *LSI-Lastem – InfoGAP - Babuc ABC - Setup V4-5* program;

3. Select the serial number of the instrument and press OK;

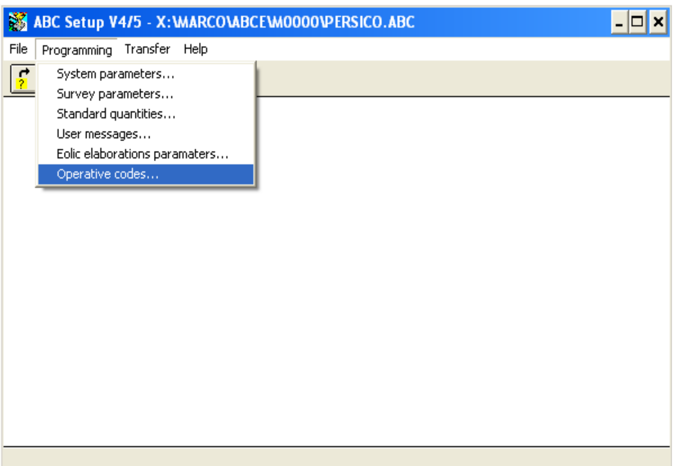


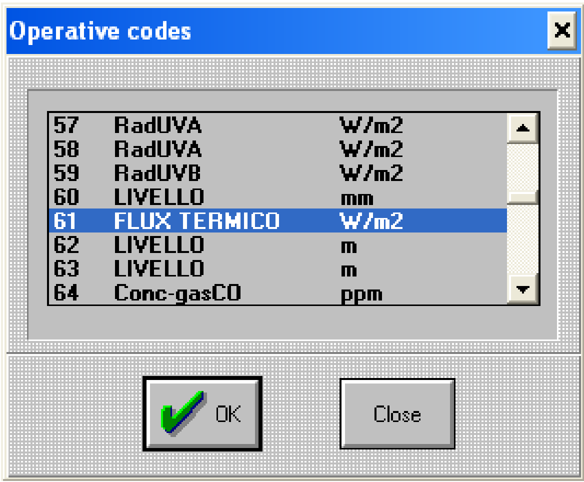


4. From starting menu select *Serial line setup*;

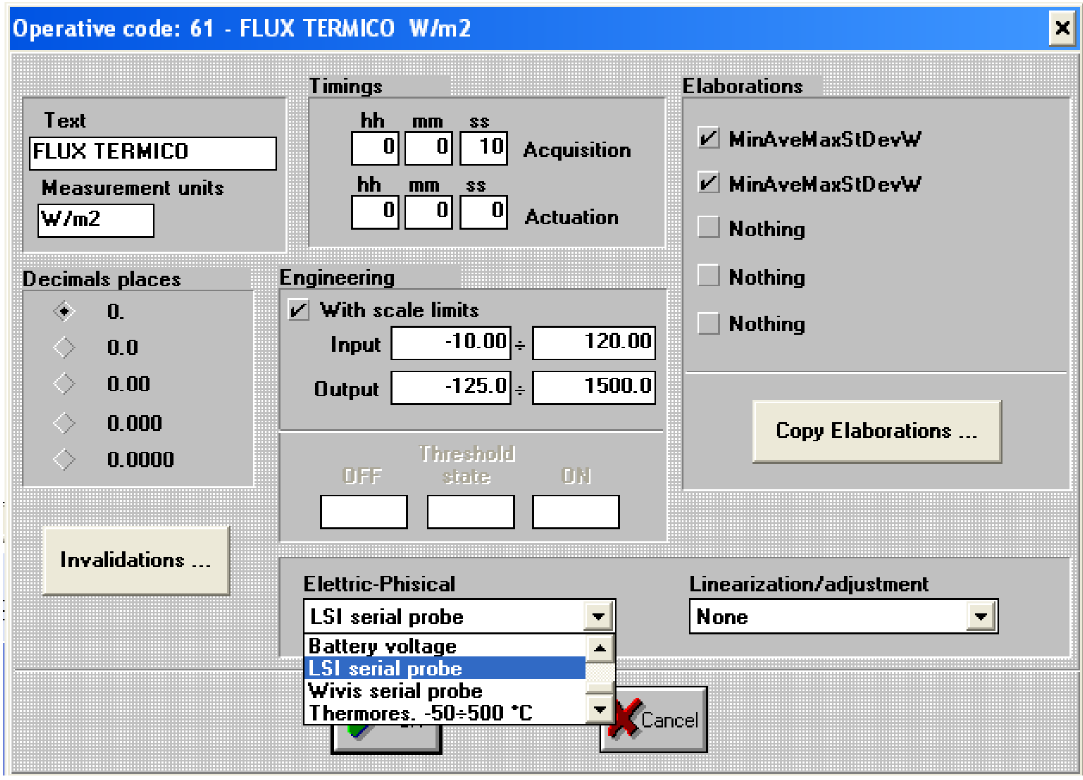


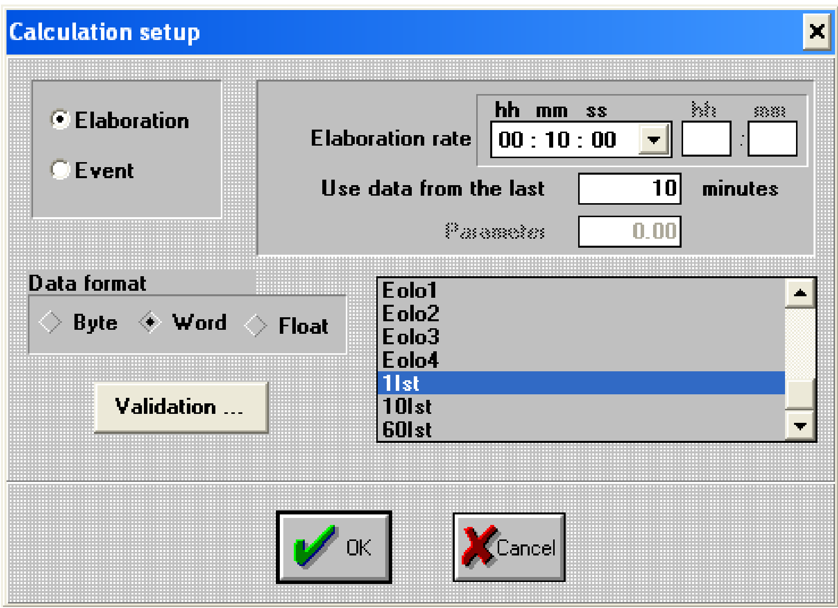
5. Connect the DEB515 cable to serial 1 of BabucABC and to first selected serial of PC;
6. From menu *File* select *Receive configuration* (the survey of BabucABC Not started); await for the reception of the configuration;
7. Select menu *Programming – Operative Codes* and open THERMAL FLUX 61 and press OK;



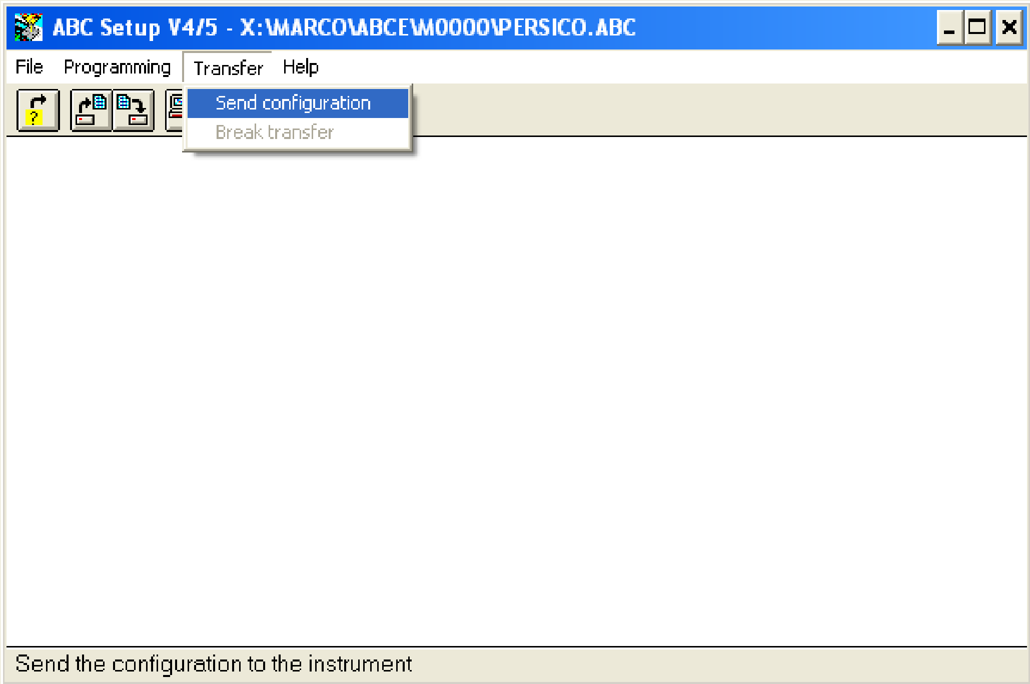


8. In the following mask modify:
   a. *Text* of the quantity (i.e.. TeEXTNord1, TeINTSud2, max 12 characters);
   b. *Acquisition - Actuation*: corresponding to that programmed in cordless sensor (def. 15 minutes);
   c. *Engineering with scale limits*: not ticked off (disabled);
   d. *Elettric - Phisical*: LSI serial sensor;
   e. *Linearization/adjustment*: anyone.
   f. As regards the produced processings it's useful remove the daily processing because it isn't used (remove the tick from the box of second line *Elaborations,* above shown with *MinMedMaxDvStW)*, and it's necessary modify the hourly processing (first line *MinMedMaxDvStW),* in this way it becomes one *1Ist* type processing with time-gap of 15 minutes:





9. Following the same procedure it's possible modify the names and the characteristics of other 3 temperatures using the operation codes recommended before;
10. Send new configuration to BabucABC.



7.1.2.Programming of the inputs

When BabucABC has been configured by Setup program correctly, arrange the programming of new inputs, i.e. specify which sensors have to be sampled and processed. This operation happens by means of keyboard and display of the instrument.

1. Go into BabucABC menu *System – Config. Input chan.*;
2. Select the operation code programmed previously;
3. Input the ID number (it usually corresponds to last three numbers of the cordless sensor's serial number) and the input number of the acquired quantity, like specified in the following table (ID 123, 124 and 125 are shown like an example; they have to correspond to real ID of the used cordless sensors):

LSI LASTEM Code	Quantity	N° Babuc input with automatic numbering	ID cordless	Cordless input
DME809 ID 123	Input 1 flow	11	123	1
	Input 2 Temperature	12	123	2
	Input 3 Temperature	13	123	3
	Input 4 Temperature	14	123	4
DME809 ID 124	Input 1 flow	15	124	1
	Input 2 Temperature	16	124	2
	Input 3 Temperature	17	124	3
	Input 4 Temperature	18	124	4
DME809 ID 125	Input 1 flow	21	125	1
	Input 2 Temperature	22	125	2
	Input 3 Temperature	23	125	3
	Input 4 Temperature	24	125	4

4. At the end start the survey and check the correct acquisition of the data from sensors through the display of the instantaneous values of the measures (await for the sampling of the data; it usually needs the twice of the set-up acquisition time-gap)

8.Use of SCRicIG

SCRicIG application may be used instead of datalogger *E-Log* and *BabucABC* in case PC may be left on near the area of measures survey; it may also disconnected from power supply (if operation assured). In this case a portable computer is usually suitable choice.

The installation of *InfoGAP K Edition* program obtains easily a ready-to-use configuration in which is already arranged the use of one or more *DME809* sensors. At the end of the program's installation procedure, *KConfig* program will be started automatically; this program configures the *DME809* used sensors.

Before the installation of *InfoGAP K Edition* program make sure that *InfoGAP* hasn't been already installed into PC.

Since beginning the program allows the use of one *DME809* sensor at least; it's possible add new *DME809* sensors pressing key *Add.* In any case you have to specify the univocal *Id* for every sensor of the list; in order to do it, at first select the sensor in the list, then press key *Edit*; the sensor *Id* corresponds to last three numbers of serial number, that is printed on the back of the sensor's container.

At the end of the procedure close *KConfig* application. *SCRicIG* program now is ready to start: it uses PC's serial line 1 like default set-up; in case you use a different serial port, modify this parameter by *SCRicIG* application; make reference to on-line guide for further details.

9.Use of InfoGAP and InfoFlux processing programs

The processing of the data collected by the system happens by means of *InfoGAP* and *InfoFLUX* programs. *InfoGAP* (also available in *K edition* version) storages the sampled data into a file (both data coming from *Babuc A/M, E-Log* and *BabucABC* acquirers and data stored by *SCRicIG* application) and allows first evaluation about time trend; *InfoFLUX* allows the calculation of the thermal transmittance. Two programs match in the following way: *InfoGAP* exports the data on ASCII file and *InfoFLUX* imports the same file.

InfoFLUX needs an exact sequence of the columns of the data included into ASCII file:

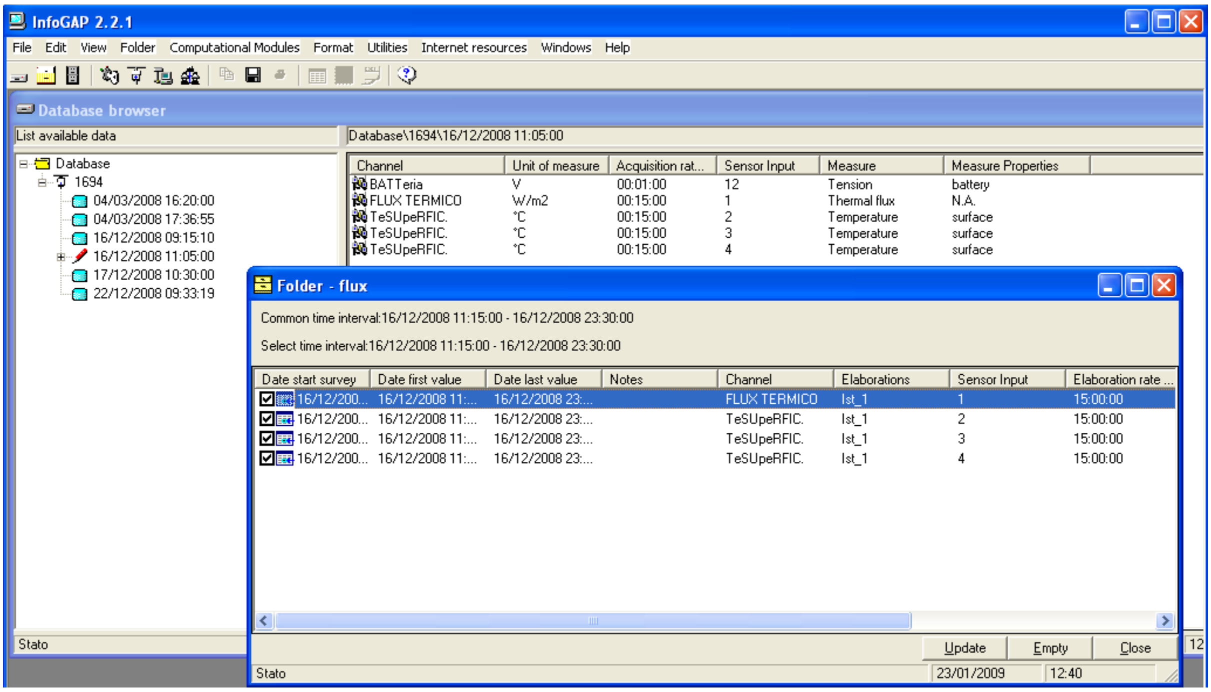
Column 1: date / hour;
Column 2: flow;
Column 3: inside temperature;
Column 4: outside temperature 1;
Column 5: outside temperature 2.

If 4 temperature probes have been used, this is the sequence of data columns:

Column 1: date / hour;
Column 2: flow;
Column 3: inside temperature 1;
Column 4: inside temperature 2;
Column 5: outside temperature 1;
Column 6: outside temperature 2.

and the exportation from InfoGAP has to be obtained following points below:

1) Start *InfoGAP* program; it's considered that the data coming from the acquisition instruments have been already stored into program's file
2) Select (from the file's navigator) the instrument and the survey that contains the data to scan;
3) Select the quantity *FLUX termico* and *Insert in the folder* by means of mouse's right key or from menu *Edit*; new window opens and shows that all processing's elements of that quantity (minimum, average and maximum values) are selected for next processings; tick-off and activate only box of average value (it's the only value that interests to *InfoFLUX* program); or keep the already ticked-off box in case the acquirer has been programmed to store only the instantaneous value every 15 minutes;

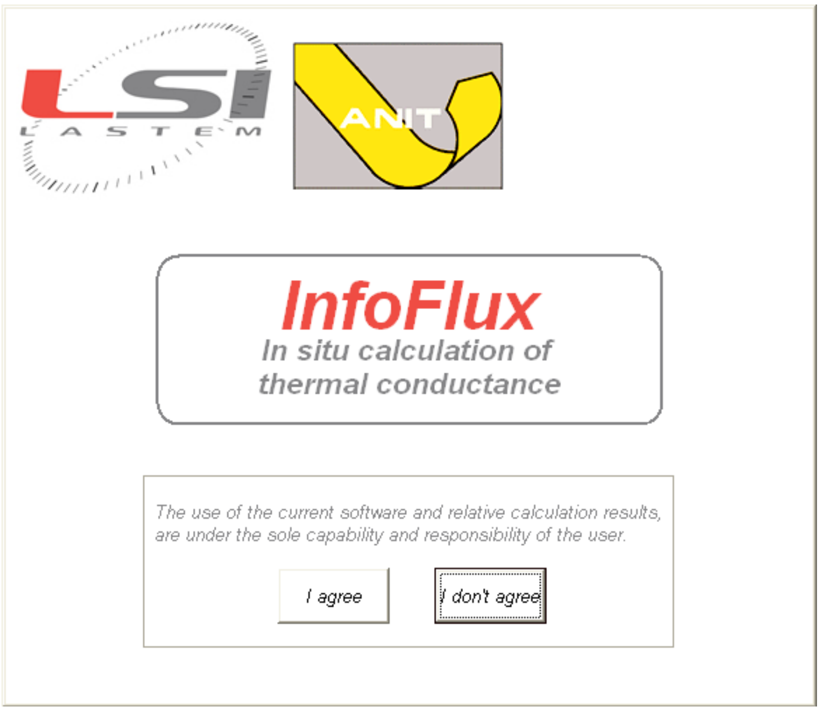


4) Return into navigator and repeat the previous procedure following the choice sequence of the quantities *Inner temperature (two, if available)*, and then two quantities *Outer temperature*; the quantities *temperature* may have the same name, so to find out the inner one, use the number of acquisition channel of the instrument; furthermore it's possible carry out a graphics preview (from *InfoGap* program) that shows the quantity's trend in time of the inner temperature and outer temperature too;
5) Return to file-holder and select the processing interval (*Select Interval*) from menu *Folder* or press right key of the mouse on file-holder's window; if you want, you can set-up the starting-time of the period so that it's rounded-off/up to quarter of an hour (i.e.. 15:00, 15:30, 15:45);
6) Select the option *Elaborate data every* and input a processing period of 15 minutes (0-0-15-0); select the option *Use the original data* in case the instantaneous values have been stored at 15 minutes intervals.
7) Carry out the data extracting and, after fast check, display them into a table (pressing right key of the mouse on the file-holder window and selecting *Table*); it has to show the data collected by the system during specified period;
8) If the table shows the expected data, export them as follow: return into file-holder and, pressing the right key of the mouse on its window, select *Save on file*...(it's available for *InfoGAP* 2.1.2.0 versions or newer); specify the name of new or existing text file which at the end of the exporting procedure will include the surveyed data; it's recommended to save the text file into folder Program/InfoFlux/DATI.
9) Start *InfoFLUX* application; carry out (through *Data import* key) the import of the previously created file; afterwards perform the program in order to obtain the expected processings.

For further information about the above mentioned procedures make reference to manuals of their programs.

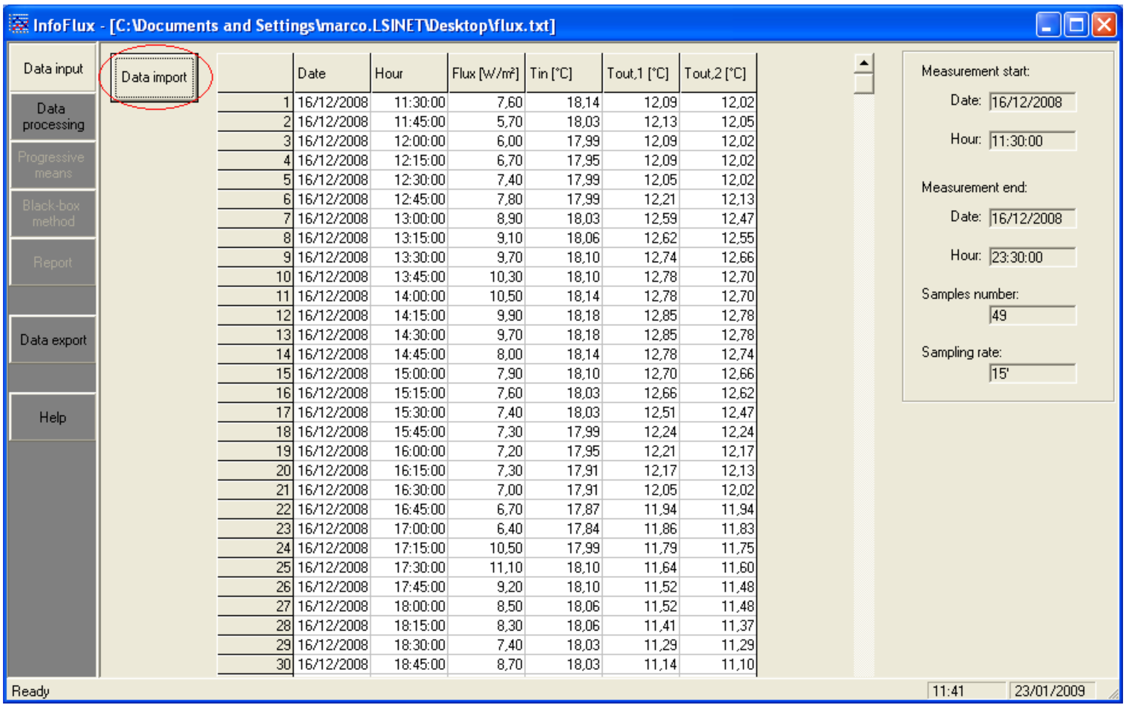
9.1.InfoFlux Program

InfoFlux program has been made in cooperation with ANIT (National Association for thermal and acoustic insulation) in order to value the thermal transmittance of a building, considering measures under way of the thermal flow and of the surface temperatures of the inner and outer side of the building. The program imports the data measured with LSI LASTEM dataloggers and sensors, processes them and calculates the conductance of the building through two different methods: the method of the progressive means and the method of black box identification.



9.1.1.Data input

Press key *Data import*; now you can see the window *Numbers of inputs* and select the number of the used channels: 5 channels (flow, 2 inner temperatures, 2 outer temperatures) or 4 channels (flow, 1 inner temperature, 2 outer temperatures). Later it'll open the dialog window *Open* that allows to select the text file of the data generated with InfoGap program, like described in previous paragraph.

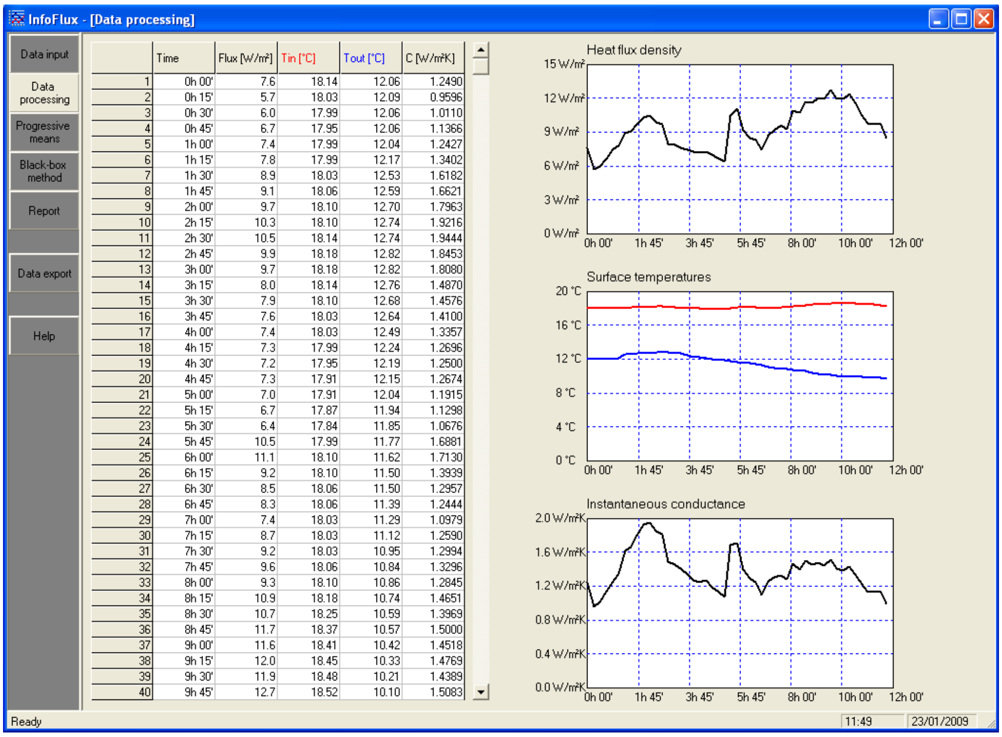


	Date	Hour	Flux [W/m²]	Tin [°C]	Tout,1 [°C]	Tout,2 [°C]
1	16/12/2008	11:30:00	7,60	18,14	12,09	12,02
2	16/12/2008	11:45:00	5,70	18,03	12,13	12,05
3	16/12/2008	12:00:00	6,00	17,99	12,09	12,02
4	16/12/2008	12:15:00	6,70	17,95	12,09	12,02
5	16/12/2008	12:30:00	7,40	17,99	12,05	12,02
6	16/12/2008	12:45:00	7,80	17,99	12,21	12,13
7	16/12/2008	13:00:00	8,90	18,03	12,59	12,47
8	16/12/2008	13:15:00	9,10	18,06	12,62	12,55
9	16/12/2008	13:30:00	9,70	18,10	12,74	12,66
10	16/12/2008	13:45:00	10,30	18,10	12,78	12,70
11	16/12/2008	14:00:00	10,50	18,14	12,78	12,70
12	16/12/2008	14:15:00	9,90	18,18	12,85	12,78
13	16/12/2008	14:30:00	9,70	18,18	12,85	12,78
14	16/12/2008	14:45:00	8,00	18,14	12,78	12,74
15	16/12/2008	15:00:00	7,90	18,10	12,70	12,66
16	16/12/2008	15:15:00	7,60	18,03	12,66	12,62
17	16/12/2008	15:30:00	7,40	18,03	12,51	12,47
18	16/12/2008	15:45:00	7,30	17,99	12,24	12,24
19	16/12/2008	16:00:00	7,20	17,95	12,21	12,17
20	16/12/2008	16:15:00	7,30	17,91	12,17	12,13
21	16/12/2008	16:30:00	7,00	17,91	12,05	12,02
22	16/12/2008	16:45:00	6,70	17,87	11,94	11,94
23	16/12/2008	17:00:00	6,40	17,84	11,86	11,83
24	16/12/2008	17:15:00	10,50	17,99	11,79	11,75
25	16/12/2008	17:30:00	11,10	18,10	11,64	11,60
26	16/12/2008	17:45:00	9,20	18,10	11,52	11,48
27	16/12/2008	18:00:00	8,50	18,06	11,52	11,48
28	16/12/2008	18:15:00	8,30	18,06	11,41	11,37
29	16/12/2008	18:30:00	7,40	18,03	11,29	11,29
30	16/12/2008	18:45:00	8,70	18,03	11,14	11,10

The table shows all inputted data; on the top right you can read the concise data of the measure: start and end of measuring, number of the data and sampling interval.

9.1.2.Data processing

After their input the data must have first processing: by every time step you obtain only one value for inner temperature, consisting of the mean of measured values, and at the same time only one value for outer temperature.



	Time	Flux [W/m²]	Tin [°C]	Tout [°C]	C [W/m²K]
1	0h 00'	7.6	18.14	12.06	1.2490
2	0h 15'	5.7	18.03	12.09	0.9596
3	0h 30'	6.0	17.99	12.06	1.0110
4	0h 45'	6.7	17.95	12.06	1.1366
5	1h 00'	7.4	17.99	12.04	1.2427
6	1h 15'	7.8	17.99	12.17	1.3402
7	1h 30'	8.9	18.03	12.53	1.6182
8	1h 45'	9.1	18.06	12.59	1.6621
9	2h 00'	9.7	18.10	12.70	1.7963
10	2h 15'	10.3	18.10	12.74	1.9216
11	2h 30'	10.5	18.14	12.74	1.9444
12	2h 45'	9.9	18.18	12.82	1.8453
13	3h 00'	9.7	18.18	12.82	1.8080
14	3h 15'	8.0	18.14	12.76	1.4870
15	3h 30'	7.9	18.10	12.68	1.4576
16	3h 45'	7.6	18.03	12.64	1.4100
17	4h 00'	7.4	18.03	12.49	1.3357
18	4h 15'	7.3	17.99	12.24	1.2696
19	4h 30'	7.2	17.95	12.19	1.2500
20	4h 45'	7.3	17.91	12.15	1.2674
21	5h 00'	7.0	17.91	12.04	1.1915
22	5h 15'	6.7	17.87	11.94	1.1298
23	5h 30'	6.4	17.84	11.85	1.0676
24	5h 45'	10.5	17.99	11.77	1.6881
25	6h 00'	11.1	18.10	11.62	1.7130
26	6h 15'	9.2	18.10	11.50	1.3939
27	6h 30'	8.5	18.06	11.50	1.2957
28	6h 45'	8.3	18.06	11.39	1.2444
29	7h 00'	7.4	18.03	11.29	1.0979
30	7h 15'	8.7	18.03	11.12	1.2590
31	7h 30'	9.2	18.03	10.95	1.2994
32	7h 45'	9.6	18.06	10.84	1.3296
33	8h 00'	9.3	18.10	10.86	1.2845
34	8h 15'	10.9	18.18	10.74	1.4651
35	8h 30'	10.7	18.25	10.59	1.3969
36	8h 45'	11.7	18.37	10.57	1.5000
37	9h 00'	11.6	18.41	10.42	1.4518
38	9h 15'	12.0	18.45	10.33	1.4769
39	9h 30'	11.9	18.48	10.21	1.4389
40	9h 45'	12.7	18.52	10.10	1.5083

It displays the diagrams of flow Φ, of temperatures (inner temperature: red colour, outer temperature: blue colour) and of the instantaneous conductance, that consists of:

$$C(t) = \frac{\Phi(t)}{T_i(t) - T_e(t)}$$

9.1.3.Data export

It's possible export the data into Excel file selected by the user. This file will consist of three work-sheets that include the measured data, the processed data and the data of progressive means respectively.
The export key activates itself only when the means have been calculated.

9.1.4.Method of the Progressive Means (Average Method ISO 9869)

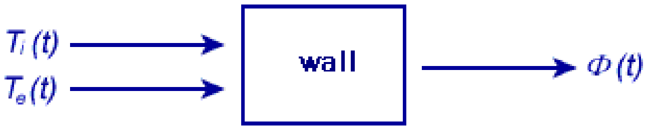
The method of progressive means calculates the conductance using at every instant the average values calculated on all previous instants, instead of the instantaneous values of flow and temperature. At every sampling instant it reports the average flow values, average temperatures and conductance (disguised as table and as diagram too). Furthermore it highlights the final values calculated using all available data.
The final value of the conductance should be the closest to the real value of the building. By the diagram you can see if the system converges or if it has still considerable fluctuations (the system may be considered like converging when its conductance value fluctuates around the horizontal asymptote with maximum range of 0.05 W/m^2K).
The U transmittance is obtained adding to the conductance the contribution of liminal resistances Rse (outer liminal) and Rsi (inner liminal); this is the formula:

$$U = \frac{1}{R_i + \frac{1}{C} + R_e}$$

In case of horizontal thermal flow (i.e. vertical walls) it's considered R_i=0,13 m^2K/W and R_e= 0,04 m^2K/W, according to tabular values under UNI EN ISO 6946 rule.

9.1.5. Black Box Method

"Black-box" is an identification method used when the physical system (in our case: the wall) isn't known; it considers only the knowledge of the time series of input data (inner and outer temperature) and output data (the flow).



Picture 9 - diagram of black-box model

By means of the data (using a statistic method) you can obtain the physical characteristics of the wall, and in this way obtain the conductance. I.e. we suppose that at some time the flow depends linearly on: the value of the same flow in previous na steps, the value of the inner temperature in previous nb1 steps and the value of outer temperature in previous nb2 steps. So we can write following formula, where the coefficients a, b1, and b2 are unknown.

$$\overline{\Phi}(t_n) + a_1\,\Phi(t_{n-1}) + \ldots + a_{na}\,\Phi(t_{n-na}) =$$
$$= b_{1,1}\,T_i(t_{n-1}) + \ldots + b_{1,nb1}\,T_i(t_{n-nb1}) +$$
$$+ b_{2,1}\,T_e(t_{n-1}) + \ldots + b_{2,nb2}\,T_e(t_{n-nb2})$$

Fix the number of steps na, nb1 and nb2, and calculate the coefficients na, b1 and b2 that minimize the quadratic deviation between the value of calculated flow and measured flow.

The program calculates all type models at change of time steps na, nb1 and nb2 (flow, inner temperature and outer temperature respectively), with:

$$na_{min} \le na \le na_{max}$$
$$nb1_{min} \le nb1 \le nb1_{max}$$
$$nb2_{min} \le nb2 \le nb2_{max}$$

For all valid models (the validity of the model depends on the tolerance t) it calculates the conductance:

$$C = \frac{\sum_{n=1}^{nb1} b_{1,n}}{1 + \sum_{n=1}^{na} a_n} = \frac{-\sum_{n=1}^{nb2} b_{2,n}}{1 + \sum_{n=1}^{na} a_n}$$

Using the obtained values, it calculates the average conductance and the standard deviation.

In order to start the calculation the user has to input following parameters::

- *na* minimum and maximum;
- *nb1* minimum and maximum;
- *nb2* minimum and maximum;
- tolerance t.

9.1.5.1.Selection of the parameters

Here below you can find the qualitative information about the selection of the parameters.

In winter measures the dependence of the flow value at *t* time on other values of temperature and flow of the number of previous time steps usually configures as follow:

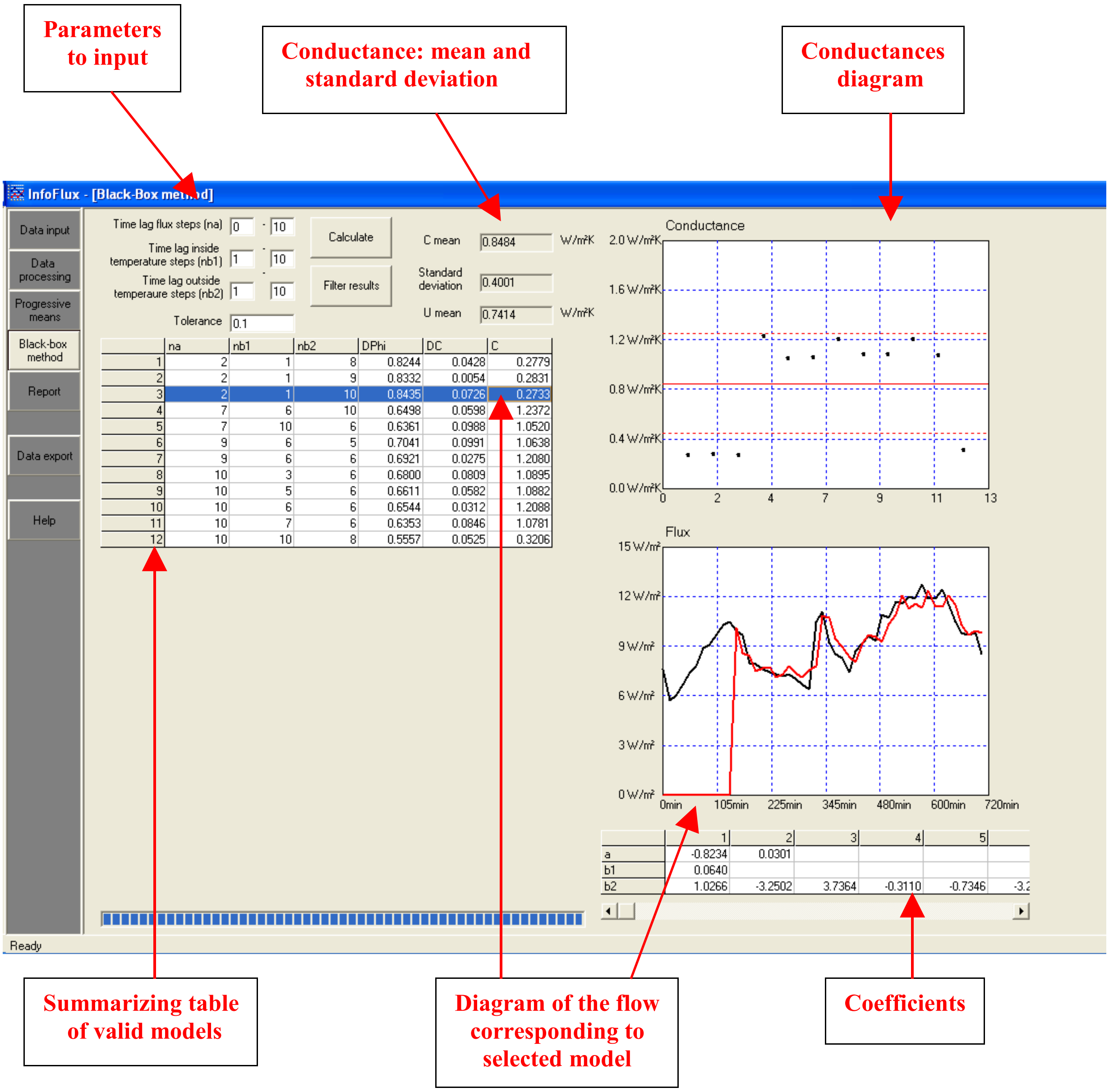
na: the previous flow values (that are usually changeable, but don't have excessive ranges) may be considered up to max 2.5 previous hours (1-10 time passages);
nb1: the values of inner temperature (that usually have a fluctuation range of 3-4°C) may be considered up to max 2.5 previous hours (1-10 time passages);
nb2: the values of outer temperature (that usually have wide fluctuations >10°C) influence the flow measured at t0 time in measure of supposed time-lag value of the wall; this value may be calculated (UNI EN ISO 13786) or may be estimated considering the type of wall. The table summarizes some values that are usually considered like valid time-lag values. The time passages are valid around the estimated time-lag, i.e. the direction is: during 8 hours from 30 to 32 passages and not from 1 to 32 previous time passages.

Wall type	Time-lag
Wall made of high thickness filled bricks (> 100 cm)	> 40 h
Wall made of high thickness filled bricks (> 50 cm)	20 - 40 h
Wall made of middle thickness filled bricks (> 25 cm)	8 - 20 h
Double boarding made of hollow bricks with interspace (30 cm)	6 - 10 h
Cls prefabricated panel	4 - 6 h

For measure conditions different from the mentioned cases, the coefficients have to be valued every time, taking into consideration the parameter that influences the flow measured at *t* instant.

When the parameters have been inputted press key "Calculate" that starts the calculation of all models at change of same parameters. In the summarizing table you can see the na, nb1 and nb2 parameters for which there are valid models, and furthermore following quantities:

- Dphi = quadratic deviation between calculated flow and measured flow;
- DC = difference between the conductance calculated using b1 coefficients and the conductance calculated using b2 coefficients;
- C = average value of two conductances at above point .



It calculates the Cm mean and the s standard deviation of the C conductances. These may be read on the top right of the diagram, the continuous red line indicates the Cm average value and two broken lines have level Cm - s and Cm + s.
Selecting one row of the results table it draws the diagram of the flow calculated using the corresponding model (calculated flow: red colour; measured flow: black colour) and reports into the below table the a, b1 and b2 coefficients.
The key "Filter results" deletes all models that have C conductance not included inside the interval [Cm - s , Cm + s] and recalculates the mean and the standard deviation on the base of left models.

Select tolerance value t=0.05 and you should obtain 50 operative models at least; in this way the result could be considered like valid value.

Also in this case the U transmittance is obtained adding to the conductance the contribution of liminal resistances Rse (outer liminal) and Rsi (inner liminal); this is the formula:

$$U = \frac{1}{R_i + \frac{1}{C} + R_e}$$

In case of horizontal thermal flow (i.e. vertical walls) it's considered R_i=0,13 m^2K/W and R_e= 0,04 m^2K/W, according to tabular values under UNI EN ISO 6946 rule.

9.1.6. Condition of use of two conductance calculation methods

The utilization conditions of two proposed calculation methods are the following:

- Thermal flow with not too reduced values: on average flow value Φ > 5 W/mq;
- Temperature difference on average *ΔT > 10 °C*.

If before and during the measure it develops a stationary condition and the wall (owing to its time-lag) is "gone on steady state" we recommend to use the method of progressive means.

If the condition is variable and the wall has a maximum time-lag of 10 hours it's possible use both methods.

If the condition is highly variable and/or the wall has high time-lag values we recommend to use the black box method.

The use of both methods (if possible) gives conductance values with differences of about 5% maximum.

9.1.7. Statement

InfoFlux program produces a statement where the user may write the information about the header and select the data tables and the diagrams that he want include. The statement may be printed and stored in DOC or HTLM format.