



LABORATORY OF ENGINEERING SYSTEMS LLC

The largest manufacturer and supplier
of greenhouse engineering systems

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Irrigation and fertilizer dosage system

Irrigation unit





Moscow 2021

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1. System use

The plant nutrition control system (*Irrigation unit*) is designed for the automated preparation of irrigation solutions with a given amount of nutrients, for planning and daily irrigation in greenhouses.

This unit allows you to organize an individual supply of nutrient solution for individual fragments of the greenhouse (zones) with control of irrigation by time and solution consumption. Using a set of tasks, you can optimally plan the intensity of watering during the day. Irrigation intensity, irrigation volume and composition of the solution can be automatically adjusted depending on the influx of solar radiation, humidity and temperature of the air or soil.

A dosing system for liquid mineral fertilizers controlled via the controller ensures the preparation of fertilizing solutions with an accurately maintained concentration of nutrients. The parameters of the nutrient solution are maintained at a given level by means of continuous double measurement of the EC and pH of the solution, as well as regulation of the supply of nutrient solutions and irrigation water.

The dosage control is fully automated and allows automatic change of the nutrient solution formulation per each watering during the day.

The controller daily calculates total watering time and solution flow for the day, watering time and solution flow through each watering valve. Additionally, the solution parameters (EC, pH and temperature) passing through each valve are averaged daily. The LIS irrigation unit controllers can be networked and connected to a personal computer (PC). At the same time, you can transfer irrigation tasks from a PC and control the irrigation process in detail, as well as print reports, archives and much more.

2. System composition

The irrigation and dosing system of liquid mineral fertilizers is controlled by an electronic unit, which includes a controller, an interface part, indication and control elements. The interface part contains control keys for pumps, irrigation valves, valves for supplying nutrient solutions and circuits for measuring electrical conductivity, acidity, solution temperature, solar radiation and liquid level in the water storage tank. If it is necessary to connect the LIS controller and a personal computer, the interface part can be supplemented with **RS-485 converters**, communication cables and PC software.

Basic technical details of the dispenser components:

2.1 EC sensor of the irrigation solution. This sensor is designed to measure the specific electrical conductivity of water solutions in the range of 0.1-6 mS / cm. It contains two chemically resistant electrodes and a built-in temperature sensor for temperature correction measured by EC. The sensor is powered by an alternating current of 16 kHz.

2.2 PH sensor of irrigation solution. The sensor is designed to measure the acidity of water solutions in the pH range from 2 to 10.



2.3 Supply valve. The valve is designed to control the nutrient solution supply to the ejection pump. It opens with 24V or 220V alternating voltage.

2.4 Ejection pump (ejector) ИСР-3-700-1/2. The ejector is designed to supply nutrient solution to the mixer tank. The capacity of one pump is up to 720 l/h of nutrient solution. The overall dimensions of the ejector are 100x26x35 mm. It is installed on the pipeline using a threaded connection.

3. Technical details

1. Irrigation unit capacity, m³/h	up to 100 m ³ /h
2. Ejection pump capacity, l/h	300-720
3. Water pressure at the ejector inlet, MPa	0,3
4. The number of possible TASKS per day, pcs.	up to 30
5. Interval between watering cycles, min	0-1440
6. Range of setting the watering time for the valve, min	0-99
7. Range of the solution flow rate per plant, ml	0-10000
8. Number of controlled irrigation valves, pcs.	up to 40
9. Outlet parameters for controlling the valves of the irrigation system switching voltage, V	24 (220)
switching current no more, A	1 (0,3)
10. Outlet parameters for controlling the pump start protection equipment switching voltage 50Hz, V	220 switching
current no more, A	0,3
11. Power supply of liquid level sensors, alternating current 50 Hz, V	5
12. Number of inlets for solution flow measurement, pcs	2
13. Time discreteness of the solution flow measurement l	1, 10, 100
14. Measuring range of EC solution, mCm/cm	0,1-6
15. Measuring range of pH solution 2-10	
16. Measuring range of solution temperature, °C	1-50
17. Measuring range of solar radiation, W/m²	0-1000
18. Measuring range of solar radiation wave length, nm	680-720
19. Range of setting EC solution, mCm/cm	0,5-6
20. Maintaining accuracy EC working solution, mCm/cm	±_0,1
21. Maintaining accuracy pH working solution	±_0,2
22. Power supply voltage, 3 life wires, 50 Hz, V	380
23. Power consumption, kw	2,5-15



4. Irrigation unit control



The liquid crystal matrix indicator is designed to display the state of the irrigation system and operation program. It displays up to 240 alphanumeric characters in eight lines. The keyboard of the controller is designed to select the parameters displayed on the indicator and to adjust it. Two keyboard keys have a constant meaning:

- the **"TEST"** button is intended for monitoring the unit's performance and resetting the failure. It is used for the initial controller setup as well.

- the **"ENTER / MENU"** key is intended for switching between the keyboard operation modes (the **MENU** mode and the **ENTER** mode). The other key meanings depend on the selected mode.

"MENU" mode is intended to select a parameter on the indicator that should be changed or monitored. All parameters available for monitoring and setting are organized in the controller memory in the form of a task table. Each cell of the table is a screen frame displayed on the indicator. In the **"MENU"** mode you can use the **arrow keys** to move through this table along the lines connecting the table cells and you can call the required parameter on the indicator. The meanings of the keys in the **"MENU"** mode correspond to the inscriptions at the bottom of the key:

- «**First**» - Set the marker on the first line of the main menu

- «**Last**» - Set the marker on the last line of the main menu

- Up arrow ▲** – Transit to the indication of the previous upper frame in the task table.

- Down arrow ▼** - Transit to the indication of the next down frame in the task table.

- Left arrow ◀** - Transit to the indication of the previous left frame in the task table.

- Right arrow ▶** - Transit to the indication of the next right frame in the task table.

- «**Up**» - Move up a line.

- «**Down**» - Move down a line.



If necessary, the parameter value should be corrected in the **"MENU"** mode using the keys to call the parameter to the indicator, then switch to the **"ENTER"** mode (by pressing the **"ENTER / MENU"** key) and set a new value.

"ENTER" mode is used to edit the selected parameter. In **"ENTER"** mode the keyboard buttons are used to enter the numbers 0 up to 9 written at the top of the button. In the **"ENTER"** mode the indicator is underlined by a character that can be replaced. When you press a numeric button the entered character appears in the underlined character space and the marker is shifted to the right. After dialing the full value an automatic transition to the **"MENU"** mode is performed.

The Controller Status screen frame displays the following:

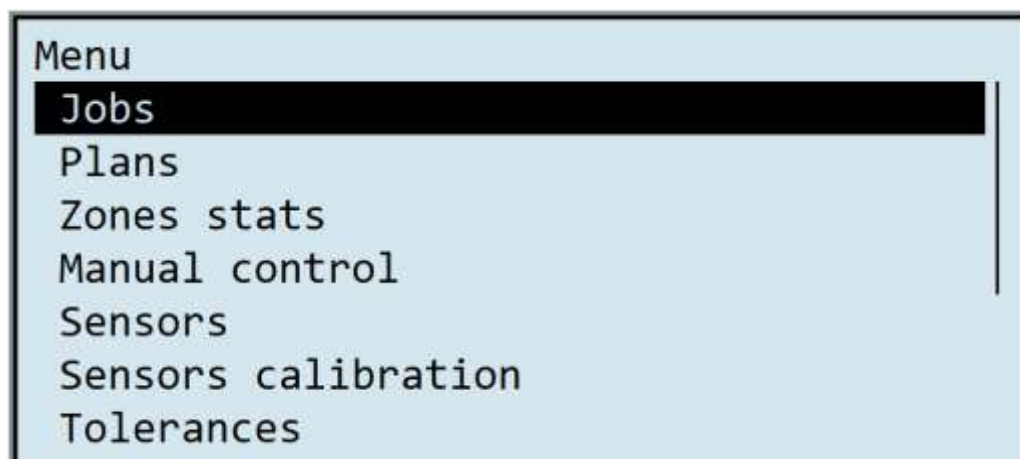
- 1) Controller time
- 2) Watering status
- 3) Meteorological data readings (accumulated solar radiation, intensity of solar radiation, temperature and humidity of the outside air)
- 4) Failure
- 5) Mode(auto/manual)

Job 1	zone 1	50:50:0:0	17:53	
EC	pH	ECd	T	Q
4.0	6.0	—	—	5.0
0.0!	11.8!	0.0!	0.0!	0.0
1.75 m³ / 8 min			≈18:01	
Waiting for the flow ...				

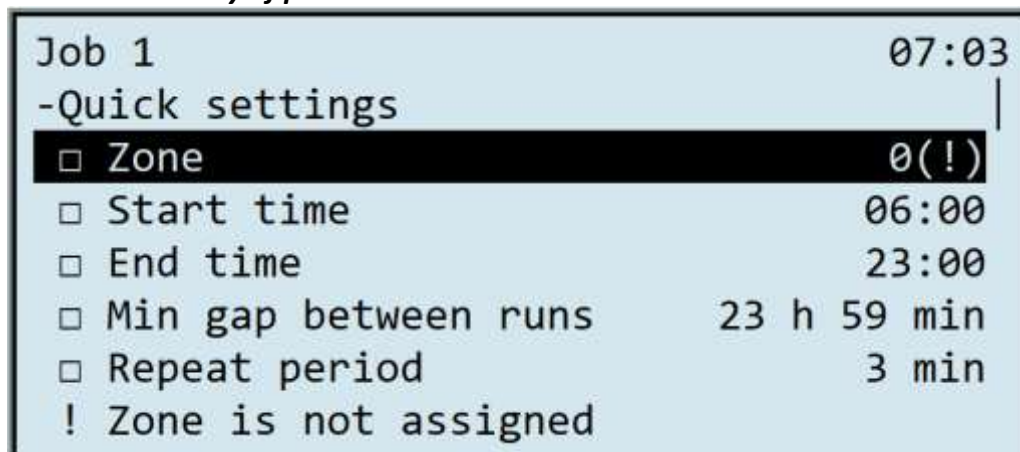
To display the **Main menu**, press the **"ENTER / MENU"** button in the **"Controller status"** screen frame. In the window that appears place the cursor on the **"MENU"** line and press the **"ENTER / MENU"** button.



Analysis of all items of the "Menu" screen frame:



The "Tasks» screen frame allows to create and edit up to 30 watering tasks in automatic mode. It supports a wide variety of parameters and conditions:



- Zone – watering zone number
- Start time – watering program start time
- End time – watering program finish time
- Min gap between runs – minimum pause time between watering cycles
- Repeat period – maximum pause time between watering cycles (from the previous start to the next start)



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- Start by sun – solar radiation value (from the previous cycle). When the value is exceeded, the irrigation cycle starts according to the **"Repeat no more often"** setting.
- Hold EC – setting the level of irrigation water electrical conductivity
- Hold pH – setting the level of irrigation water acidity
- Hold EC drainage – setting the level of inlet solution electrical conductivity (mixing water and drainage at the inlet to the "mixer")
- Dose A/B/C/D – proportions of nutrient solution intake (ratio)
- Start date – start date of the watering program
- Finish date – finish date of the watering program
- By days of the week – banning the watering program (0-no watering, 1-watering)
- Maximum number of iterations – the maximum number of watering cycles since the start
- Volume per dripper – volume of irrigation solution per one dripper for one watering cycle
- Microdose per dripper - volume of concentrated fertilizer for mixing with irrigation solution in one watering cycle
- Start by PhAR – PhAR value is exceeded, the condition for the start of the next watering cycle appears
- Start by humidity less – humidity value is exceeded, the condition for the start of the next watering cycle appears
- Start by temperature – temperature value is exceeded, the condition for the start of the next watering cycle appears
- **Corrections**
- Sun changes volume from – the value of accumulated solar radiation (from the previous cycle), when the effect on the volume of the solution begins on one dripper in one watering cycle
- Sun changes volume up to – the value of accumulated solar radiation (from the previous cycle), when the effect on the volume of the solution on one dripper in one watering cycle is maximal
- Sun changes volume by – solution correction value per dripper in one watering cycle by accumulated solar radiation
- PhAR changes volume from – PhAR value, when the effect on the volume of the solution on one dripper in one watering cycle begins
- PhAR changes volume up to – PhAR value, when the effect on the volume of the solution on one dripper in one watering cycle is maximal
- PhAR changes volume by - solution correction value per dripper in one watering cycle by PhAR
- Humidity changes volume from – humidity value, when the effect on the volume of the solution on one dripper in one watering cycle begins
- Humidity changes volume up to – humidity value, when the effect on the volume of the solution on one dripper in one watering cycle is maximal



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- Humidity changes volume by – solution correction value per dripper in one watering cycle by humidity
- Temperature changes volume from – temperature value, when the effect on the volume of the solution on one dripper in one watering cycle begins
- Temperature changes volume up to – temperature value, when the effect on the volume of the solution on one dripper in one watering cycle is maximal
- Temperature changes volume by - solution correction value per dripper in one watering cycle by temperature

Note.

- *To activate the watering task, specify the start-end times, minimum pause, maximum pause, volume per dripper*
- *Do not specify “Hold EC and pH” for watering without dosing fertilizers / acid*
- *To correct the specified watering parameters according to outside conditions, set the correction interval (from / to) and the correction value. All corrections are linear. If the correction value is zero (0), it is inactive.*

The “Watering Plan” screen frame allows you to attach irrigation valves to a specific zone, grouping multiple valves (if necessary) into one zone. Besides, a number of parameters are set for each valve, which are necessary for calculating the flow rate and pressure during the irrigation unit operation:

Plans	
Valve 1	zone 01
Valve 2	
Valve 3	
Valve 4	
Valve 5	
Valve 6	
—	



Valve 1	
<input type="checkbox"/> Zone	1
<input type="checkbox"/> Attach to valve	0(No)
<input type="checkbox"/> Emitters per valve	2500
<input type="checkbox"/> Emitter flow rate	2.00
<input type="checkbox"/> Set pressure	0(Default)

- Zone – virtual zone number for grouping valves
- Attach to valve – logical connection of this valve to another for irrigation through two or more valves.
- Number of drippers – number of drippers for irrigation per valve
- Dropper capacity – dropper flow, l/h
- Hold pressure – setting the pressure for the irrigation valve (if 0, then it works according to the instructions from the block "**Advanced settings -> Irrigation pump -> Default irrigation pressure**")

Note.

- Set the zone number for each valve, since the irrigation task is set for the zone (if they are in the same zone, the task will be actual for each of the valves and watering will take place alternately for each valve in this zone. If they are connected to any of the valves, watering will occur on all connected valves at the same time).
- Number of droppers, capacity (for calculating the flow rate of the solution. If the value is incorrect, the calculations will be incorrect and a flow failure will appear)

The "Zone status" screen frame displays information about the status of each zone (set parameters, operating mode, etc.):



The "Manual control" screen frame allows to control the following mechanisms in the "manual" mode:

Manual control		
<input type="checkbox"/> Irrigation pump, bar		0(Off)
<input type="checkbox"/> Supply pump		Off
<input type="checkbox"/> Valves 1-16	<00000000 00000000>	
<input type="checkbox"/> Valves 17-32	<00000000 00000000>	
<input type="checkbox"/> A doser		0.00
<input type="checkbox"/> B doser		0.00
<input type="checkbox"/> C doser		0.00

- Irrigation pump – pump control for supplying solution to irrigation valves
- Supply pump – pump control for supplying treated water to irrigation unit mixer
- Valves 1-16/17-32 – solenoid valves control (1 – open, 0 – closed)
- Ventil A/B/C/D/pH/microdosing - for dosing fertilizers and acids into the irrigation unit mixer (% open 0-100%= time 0-8 sec.)
- Open drainage – opening the return valve
- Close drainage – closing the return valve

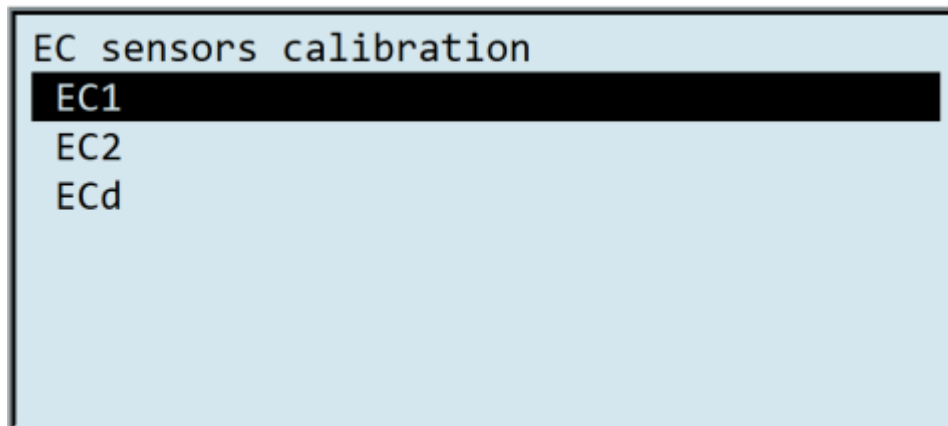
The "Measurements" screen frame displays the measuring sensor readings of the irrigation unit, as well as the measurement status (! - measurement process error):

Sensors	
→ EC1, mS/cm	0.00!
→ EC2	0.00!
→ pH1	17.35!
→ pH2	17.35!
→ ECd	0.00!
→ Flow	0!
→ Pressure	-1.50!



- EC1/EC2/ECdrainage – readings of electrical conductivity of the first, second sensor and drainage mixing sensor
- pH1/pH2 – readings of acidity of the first, second sensor
- Flow – flow meter reading
- Pressure – pressure sensor reading
- Temperature –water temperature sensor reading at the inlet of the irrigation unit
- Level at the water supply – treated water at the inlet of the irrigation unit
- Level inside the tank – solution inside the irrigation unit mixer
- Drainage level – drainage solution
- PhAR – solar radiation intensity
- Sun energy – accumulated solar radiation
- Outside temperature – outdoor air temperature
- Outside humidity – relative humidity of the outdoor air
- Filling level – water storage tank filling level sensor
- Additional level – additional water storage tank filling level sensor (drainage, solution)

The "Calibrating sensors" screen frame allows to calibrate the following sensors of the irrigation unit:



- EC1/EC2/ECdrainage – selection of a conductivity sensor for calibration

The "Tolerances" screen frame allows to set the tolerance limits for the EC / PH / EC drain sensors / flow meter/ pressure sensor, as well as the discrepancies between the EC1 and EC2 sensors; PH1 and PH2 sensors.

The «EC tolerance" screen frame:



Tolerances

EC tolerance

pH tolerance

Drainage EC tolerance

Flow rate tolerance

Pressure tolerance

Heating temperature tolerance

EC2/EC1 mismatch

EC tolerance

→ Measured, mS/cm 0.00

→ Expected 0.00

☐ Tolerance below 0.40

☐ Tolerance above 0.30

- Measured – current electrical conductivity reading
- Expected – set electrical conductivity value (taking into account the correction)
- Tolerance below – lower tolerance limit
- Tolerance above – upper tolerance limit

The "Alarms" screen frame allows to set alarms of tolerances, water and computer boards and also displays the status of all possible alarms of the irrigation system:



Alarms

Tolerance failures

Water failures

Board failures

Alarm relay

- Tolerance failures:
 - EC – when the conductivity of the nutrient solution deviates from the specified values by the value set within the tolerances
 - pH – when the acidity of the nutrient solution deviates from the specified values by the value set within the tolerances
 - EC drainage - when the conductivity of the nutrient solution deviates from the specified values by the value set within the tolerances
 - Pressure – when the pressure deviates from the specified values by the value set within the tolerances
 - Water consumption – when the consumption of the nutrient solution deviates from the specified values by the value set within the tolerances
 - EC2/EC1 – EC2/ EC1 alarm condition discrepancy
 - PH2/PH1 – PH2/PH1 alarm condition discrepancy
 - Active alarms – active system alarms
 - EC timeout – time before EC failure (out of tolerance)
 - pH timeout – time before pH failure (out of tolerance)
 - EC drainage timeout – time before EC drainage failure (out of tolerance)
 - Pressure timeout – time before water pressure failure (out of tolerance)
 - Water consumption timeout – time before water consumption failure (out of tolerance)
 - EC2/EC1 timeout – time before EC2/EC1 mismatch
 - pH2/pH1 timeout – time before pH2/pH1 mismatch

In the event of EC, pH, temperature alarm, check the tolerance limits (not too small), the timeout (not too short), the presence of solutions in the tanks, the calibration of the sensors, the position of the manual ventil, the functionality of the dosing valves.



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- If a pressure or flow alarm occurs, check the irrigation plan (number and volume of drippers for each valve). Check the supply line of the nutrient solution to the irrigation valves for integrity. Check all watering valves for complete closure at the end of watering.
- If an EC or pH mismatch occurs, the calibration of the sensors must be checked. Calibrate or replace and recalibrate the sensors.
- Water failures:
 - Water in the tank - water in the water storage tank
 - Water inlet – water in the irrigation unit mixer
 - Active alarms – active alarms of the system
 - Timeout of water in the tank – time before the failure when the water absence in the water storage tank
 - Timeout of water inlet – time before the failure when the water absence in the mixer
- In the event of a water alarm, check water, the presence of a corresponding signal from the filling sensor and check the filling sensor itself.
- Board failures
 - EC board– EC board failure status
 - pH board– pH board failure status
 - Level board– Level board failure status
 - Inlet board – Inlet board failure status
 - Relay board – Relay board failure status
 - Valve board 1 – Valve board 1 failure status (from 1 up to 16)
 - Valve board 2 – Valve board 2 failure status (from 17 up to 32)
 - Frequency controller – Frequency controller failure status of the irrigation pump
 - Active alarms – display of active alarms in line format (1 - failure, 0 – no failure)
 - EC board timeout – time before EC board failure
 - pH board timeout – time before pH board failure
 - Level board timeout – time before level board failure
 - Inlet board timeout – time before inlet board failure
 - Relay board timeout – time before relay board failure
 - Valve board 1 timeout– time before Valve board 1 failure (from 1 up to 16)
 - Valve board 2 timeout– time before Valve board 2 failure (from 17 up to 32)
 - Frequency controller timeout – time before frequency controller of the irrigation pump failure



In the event of a board failure, check the correspondence of the board address in the controller and its actual address (on the ID selector). Reboot the system. Replace the board, if the failure recurs.

The "System configure" screen frame allows to set a number of basic settings for the controller of the irrigation system:

System config	
<input type="checkbox"/> Time	12.04.21 08:14:49
<input type="checkbox"/> Language	English
<input type="checkbox"/> IP port	69
<input type="checkbox"/> MB port (after reboot)	7
<input type="checkbox"/> Shared data group	239.255.0.1
<input type="checkbox"/> Shared data port	2000
<input type="checkbox"/> Shared data send period	30

- Time– date and time (set the correct date and time settings for the irrigation unit to work correctly with PC)
- Language – controller interface language (Russian / English)
- IP address – data transmission IP address
- IP port – data transmission IP port (standard 69)
- Shared data group – shared data group address (meteo multicast)
- Shared data port – shared data port transmission (standard 2000)
- Shared data send period – shared data send period interval (sec.)
- Passcode – numeric code to unlock the controller
- Server syslog – IP address of the PC for collecting data of the controller operation

The "Advanced settings" screen frame provides access to setting up various subsystems and individual sensors and mechanisms, some of them see in the example below:



Menu

Jobs

Plans

Zones stats

Manual control

Sensors

Sensors calibration

Tolerances

EC1 sensor

= Measured

0

= Status

Connecting...

□ Board address

6

□ Register number

2008

i Momentary status

Connecting...

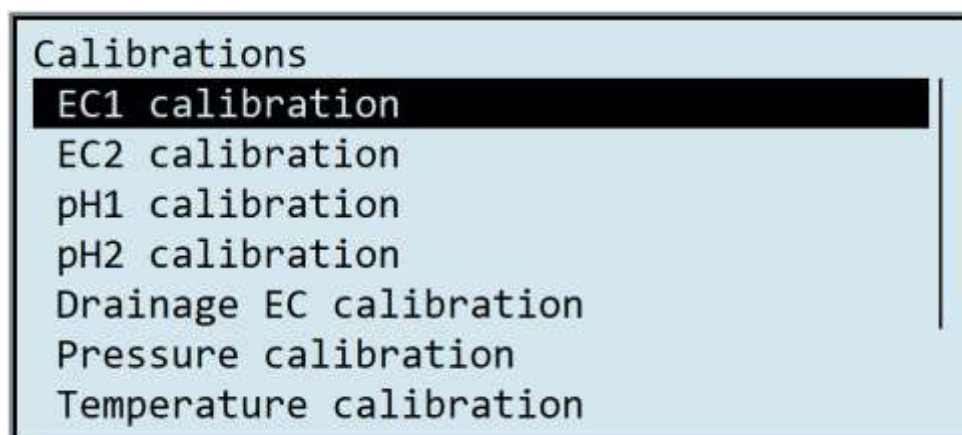
i Last timestamp

No

- Measured – actual reading of the EC sensor
- Status – operation status EC sensor
- Board address – address of the measurement board connected to this sensor
- Register number – the register number for the operation of a specific sensor corresponding to the inlet on the measurement board
- Momentary status – current sensor status
- Last timestamp – time of the last sensor activity

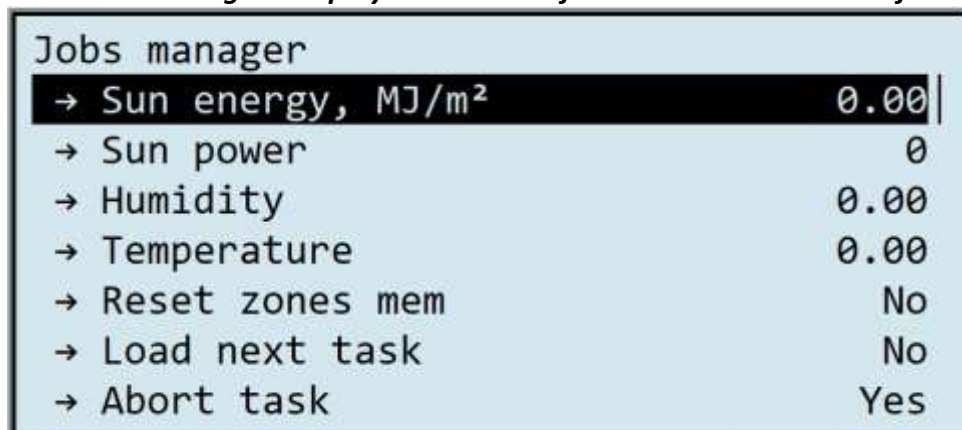


The "Calibrations" screen frame allows to calibrate the sensors of the irrigation unit. We will consider in detail the sensor calibration in the paragraph CALIBRATION OF SENSORS.



The "Control" screen frame permits the following screen frames:

The «Jobs Manager» displays the status of all tasks and conditions for irrigation operation.



- Sun – accumulated solar radiation reading (MJ/m²)
- PhAR – solar radiation intensity reading (W/m²)
- Humidity – relative humidity reading
- Temperature – Water temperature reading
- Reset zone memory – zone memory reset status
- Load next task – loading status of next task
- Abort task – task reset status
- Valves 1-16/17-32/33-40 – Irrigation valves status (0-closed, 1-open)



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- Hold EC – EC setting (taking into account corrections)
- Hold pH – pH setting (taking into account corrections)
- Hold temperature – water temperature setting
- Hold EC drainage – EC setting for inlet mixing
- Hold pressure – Water pressure setting
- Dose A/B/C/D – ratio to the other doses setting
- Watering volume – the watering solution volume
- Required flow – calculated flow
- Microdose volume – specified volume of microdosing
- Valves pending – the number of irrigation valves that are waiting to open
- Tasks – detailed information for a specific task
- Valves – detailed information for a specific valve
- Start by sun – operation permits for this correction
- Start by PhAR – operation permits for this correction
- Start by humidity – operation permits for this correction
- Start by temperature – operation permits for this correction
- Change volume by sun – operation permits for this correction
- Change volume by PhAR – operation permits for this correction
- Change volume by humidity – operation permits for this correction
- Change volume by temperature – operation permits for this correction
- Change EC by sun – operation permits for this correction
- Change EC by PhAR – operation permits for this correction
- Change EC by humidity – operation permits for this correction
- Change EC by temperature – operation permits for this correction
- Change dose by sun – operation permits for this correction
- Change dose by PhAR – operation permits for this correction
- Change dose by humidity – operation permits for this correction
- Change dose by temperature – operation permits for this correction
- Zones – detailed information for a specific zone
- Active task – the register number of the task that is currently active
- Task period – period of the task validity
- Estimated period of the task – estimated period of the task validity
- Sun between starts – accumulated sun since the start of the last watering cycle
- Volume per dripper – the irrigation solution volume set in the task (taking into account the correction) per one dripper
- Zone number – zone number for watering
- Valve number – valve number for watering
- Additional valves – number of irrigation valves attached to "Valve number"



- Time for subsequent valves – calculated run time for subsequent irrigation valves
- Volume for subsequent valves – calculated water volume for subsequent irrigation valves
- Next scheduled task – start time of the next scheduled task
- Next conditional task – start time of the next task by condition, i.e. taking into account the correction

The screen frame "Automatic irrigation" displays the status of all subsystems, sensors and mechanisms at a given time

Irrigation machine	
→ Flow rate, l/h	0.00
→ Volume increment	0.00
→ Mix is ready	Yes
→ Irrigation volume	0.00
→ Required flow	0.00
→ Tank level	0
→ More tasks to follow	No

- Water consumption – water consumption for irrigation
- Volume increment – difference between measured and set value of irrigation water volume
- Mix is ready – readiness status of the solution in the mixer
- Irrigation volume – the amount of irrigation solution that remains
- Required flow – calculated flow rate for watering
- Tank level – water level in the water storage tank
- Cancel task – task cancellation status
- Load task – task loading status
- Open valve – valve operation status
- Switch on the irrigation pump – irrigation pump status
- Switch on the water supply pump – water supply pump status
- Service – service authorization status
- Pause by valve change – the pause between the opening of the irrigation valves
- Solution preparation time – the time before opening the irrigation valves required to prepare the solution in the mixer
- Maximum tank filling time – maximum time required to fill the mixer



- Tank volume – the volume of the irrigation unit mixer tank
- Drain the remainder – Remainder drain status (empty pipes for irrigation after completing a task)
- Status – general status of automatic watering
- Time left – time until the task end
- Consumed volume – the amount of irrigation water consumed onto the active valve
- Volume left – the amount of irrigation water to be consumed onto the active valve
- Drain limit at the task end – running time of the irrigation pump to empty the mixer
- Timeout dosing pump washing - irrigation pump run time before the end of the irrigation cycle without dosing fertilizers and acid
- Active failure – active failure number
- Pause – pause status of the irrigation unit operation program

The "Filter washing service" screen frame allows to set filter washing in automatic mode, as well as to wash the filter in manual mode:

Backwash service	
→ Filter is used	No
→ Volume increment	0.00
→ Wash allowed	No
→ Command	No
= Need to wash	No
= Wash	No
□ Run by time	2 min

- Filter is used – filter permission status
- Volume increment – difference between measured and set value of irrigation water volume
- Wash allowed – filter washing permission status
- Command – external command to start filter washing
- Need to wash – the status of the need to wash the filter
- Wash – command to start washing the filter
- Run by time – operating time of the irrigation unit, after it the filter will start washing in automatic mode
- Run by volume – the volume of the consumed solution to start washing the filter in automatic mode
- Wash time – filter washing time



- Volume from the last wash – the volume of the consumed solution from the last washing of the filter
- Time from the last wash – operating time of the irrigation unit since the last washing of the filter
- Time until the washing – the remaining time until the end of the filter washing

Levels for filling tank	
→ %, %	0.00
= Run	Yes
<input type="checkbox"/> On threshold	81.00
<input type="checkbox"/> Off threshold	90.00

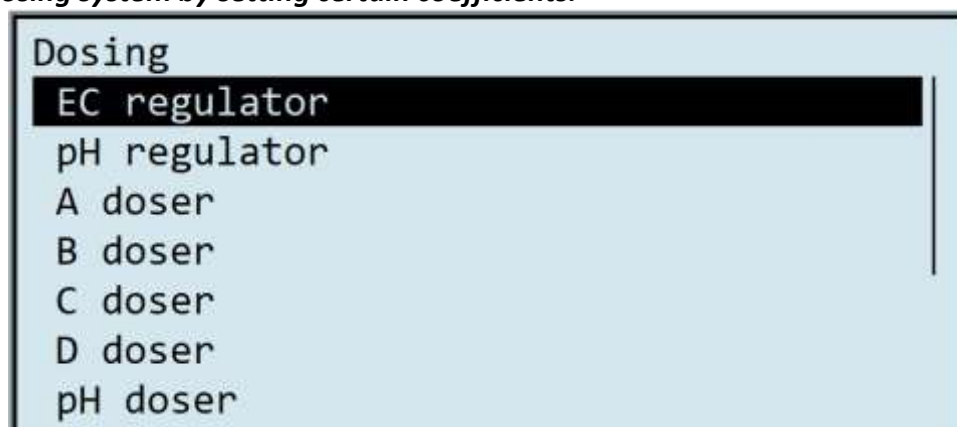
- % - filling the water storage tank %
- Run – the status of the relay for controlling the filling of water into the tank
- On threshold – water level in the tank (%), below which tank filling begins
- Off threshold – water level in the tank (%), above which tank filling stops

Levels for irregation	
→ %, %	0.00
= Run	No
<input type="checkbox"/> On threshold	20.00
<input type="checkbox"/> Off threshold	10.00

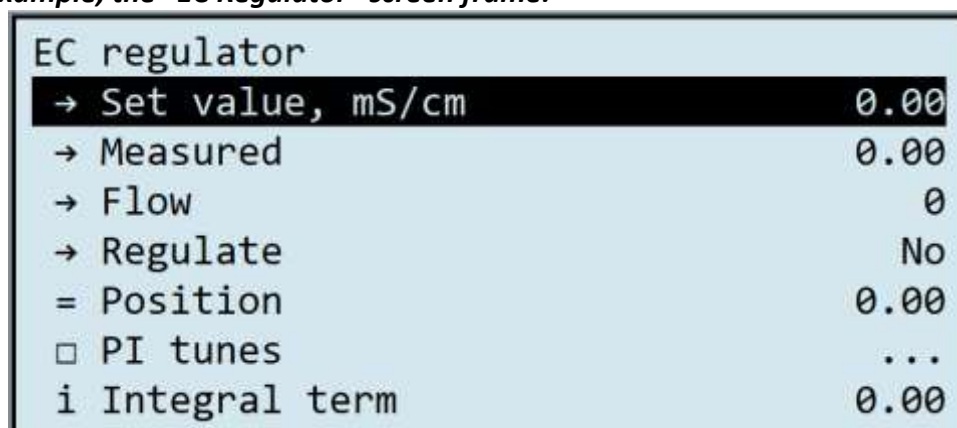


- % - filling the water storage tank %
- Run – the status of the relay for controlling the "water intake from the tank
- On threshold – water level in the tank (%), above which water intake begins
- Off threshold – water level in the tank (%), below which water intake is canceled

The "Dosing" screen frame displays information about the dosing mechanisms and also allows to adjust the dosing system by setting certain coefficients.



For example, the "EC Regulator" screen frame:





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- Set value – the set EC irrigation solution, taking into account the correction
- Measured – EC irrigation solution reading
- Flow –irrigation solution flow rate reading
- Regulate – EC regulator status
- Position – EC regulator status (%)

- Coefficients:

PI tunes

1 Min

2 Norm

3 Max

4 No flow



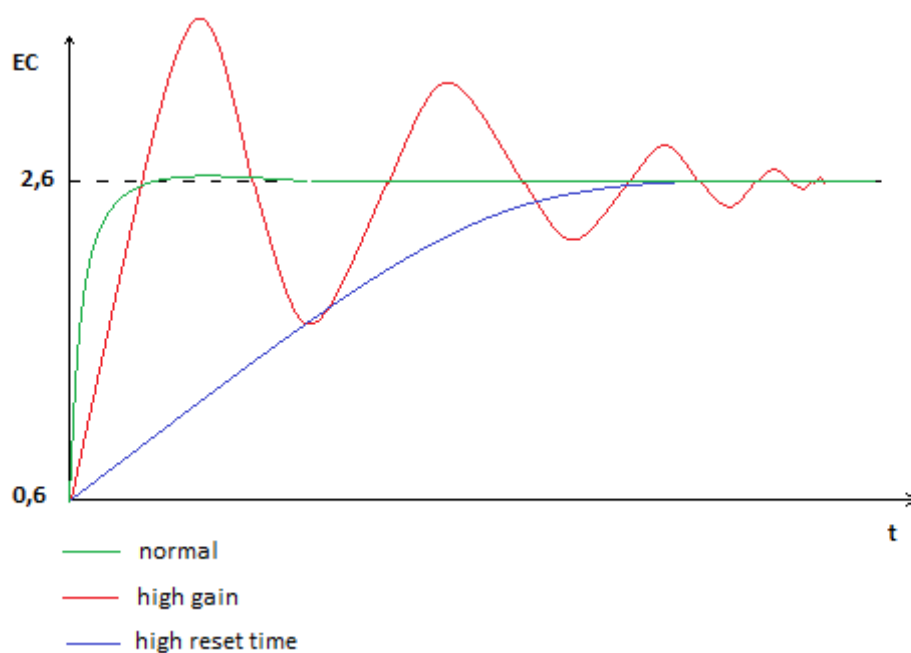
- Minimum:

PI tunes: 1 (Min)	
<input type="checkbox"/> Flow, l/h	1000
<input type="checkbox"/> Optimal position	2
<input type="checkbox"/> Max position	15
<input type="checkbox"/> Gain	3.00
<input type="checkbox"/> Reset time	27.0

- Flow – irrigation solution flow rate for which the following settings are made:
- Optimal position – EC regulator optimal position is selected empirically by increasing the value for less concentrated solutions and decreasing for more concentrated, %
- Max position – EC regulator maximal position is selected empirically by increasing the value for less concentrated solutions and decreasing for more concentrated, % Can be used to prevent overdosing
- Gain – the proportional correction. The influence on the deviation from the set values. When this value is increased, the opening percentage of the dosing valve increases, that leads to a greater dosing
- Reset time – time when the values must reach a given level. It is selected empirically by increase to achieve a task in a shorter time and by decrease to achieve a task in a longer time, in order to exclude the overdosing.

Note. The gain and the reset time are closely related. For example, in event of a sharp increase in the gain, increase the reset time, because the time must be increased to reach the set values in order to eliminate overdosing. The settings "Normal", "Maximum" and "No flow" work in the same way, but with different flow rate set in each specific screen frame.

This is for accurate adjustment of the irrigation unit under different conditions, for example different irrigation areas (valves or zones) with different characteristics (pressure, flow).



The "Irrigation pump" and "Supply pump" screen frame allow to adjust the operation of the pumps of the irrigation unit:



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Default irrigation pressure - pressure (bar) for pump operation (used for operation if no valve pressure is set).

Irrigation pressure regulator	
→ Set pressure, bar	0.00
→ Measured pressure	-1.50
→ Allow run	No
= Frequency	0.00
□ Gain	2.00
□ Time constant	1.0
□ Min freq	5.00

- Set pressure – water pressure set for pump operation
- Measured pressure – pressure sensor reading
- Allow run – irrigation pressure regulator status
- Frequency – frequency when the irrigation pump operates (0-50Hz)
- Gain – proportional correction (step)
- Time constant – integral correction
- Min frequency – minimum operation frequency of the irrigation pump (0-50Hz)
- Max frequency – maximum operation frequency of the irrigation pump (0-50Hz)
- Start frequency – start frequency of irrigation pump

Supply pump	
Supply pump protection	
Supply pump shutdown delay	



Supply pump protection	
→ Supply level ok	No
= Will shutdown in	0
□ Timeout	8 sec

- Supply level ok – water in the water storage tank status
- Will shut down in – time before stopping the water pump on inlet
- Timeout – time after which the pump protection will operate on inlet, if "Inlet level" = No

Supply pump shutdown delay	
→ Need to run pump	No
= Will shutdown in	0
□ Timeout	10 sec

- Need to run pump – the command to turn on the irrigation pump
- Will shut down in – time before stopping the water intake by the pump on inlet
- Timeout – time after which the pump protection will operate on inlet, if "Inlet level" = No

The "Heating" screen frame permits to set the mechanisms that control the irrigation water heating.



See items below:

Temperature regulator	
→ Set temperature, °C	0.00
→ Measured temperature	0.00
→ Allow run	No
= Change position by	0.00
□ Gain	40.00
□ Time constant	27.0

- Set temperature – maintaining the water temperature
- Measured temperature – measured water temperature reading
- Allow run – water heating operation status
- Change position by – temperature value %, when it is necessary to change the temperature regulator position
- Gain – proportional correction
- Time constant – integral correction

Temperature valve driver	
→ Change position by, %	0.00
→ Force close	No
→ Force open	No
→ Allow run	Yes
= Forward	No
= Backward	No
= At limit	No

- Change position by – setting the temperature gate position (%)
- Force close – forced gate closing
- Force open – forced gate opening
- Allow run – water heating operation status



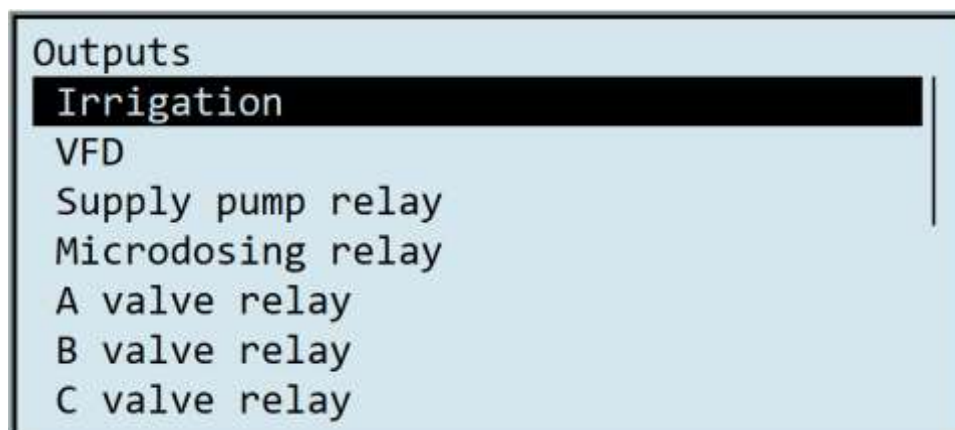
- Forward – direction towards the gate opening (to 100 %)
- Backward – direction towards the gate closing (to 0 %)
- At limit – full gate opening (%)
- Full operation time – Time of continuous gate operation from 0 up to 100 (%)
- Minimum operation – the minimum change in gate position (%)
- Remaining operation – the remaining gate operation (%)

Run temperature pupm	
→ Run	No
= Status	Ok
□ Board address	0(No)
□ Register number	1019
i Momentary status	Disabled
i Last timestamp	No

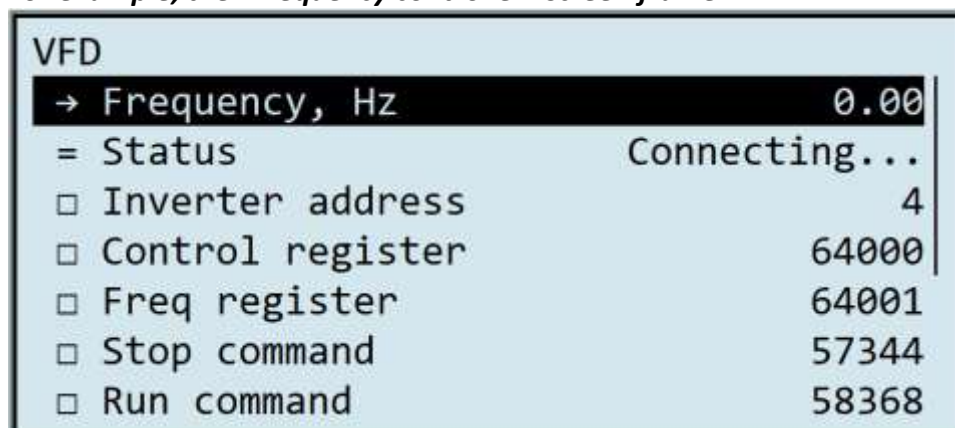
- Run – activation of the pump relay of the temperature regulator
- Status – temperature regulator pump relay board status
- Board address – relay board address connected to the temperature controller pump (set on the board by ID selector which indicator points to the register number)
- Register number – register number for the operation of a specific sensor corresponding to the inlet on the measurement board (the value is used by default and do not need to be configured)
- Momentary status – current sensor status
- Last timestamp – last activity time of the sensor

The "Temperature regulation open / close relays" are similar, but they are used to set two relays that control the "temperature gate".

The "Outlets" screen frame allows setting the "outlets", i.e. setting the irrigation unit control elements:



For example, the "Frequency controller" screen frame:



- Frequency – frequency when the irrigation pump is operating (0-50Hz)
- Status – frequency controller status
- Inverter address – register address for frequency controller inverter
- Control register – control register address
- Frequency register – Frequency register address
- Stop command – stop command register address
- Run command - run command register address



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The "About controller" screen frame displays information about the firmware version of the controller, etc.:

```
About
i build version  dev-174-g57332b8-dirty
i build date      2021-04-15
i mac address     00-00-00-00-00-00
i motohours       172

Tankless doser
```

- Version – irrigation unit controller firmware version code
- Build date – irrigation unit assembly date
- MAC address– irrigation unit controller network board MAC address
- Moto hours – operated hours for all time

i – information line (no correction);
= - calculated value line (no correction);
→- Reading line (no correction);
□ – setting line (correction).

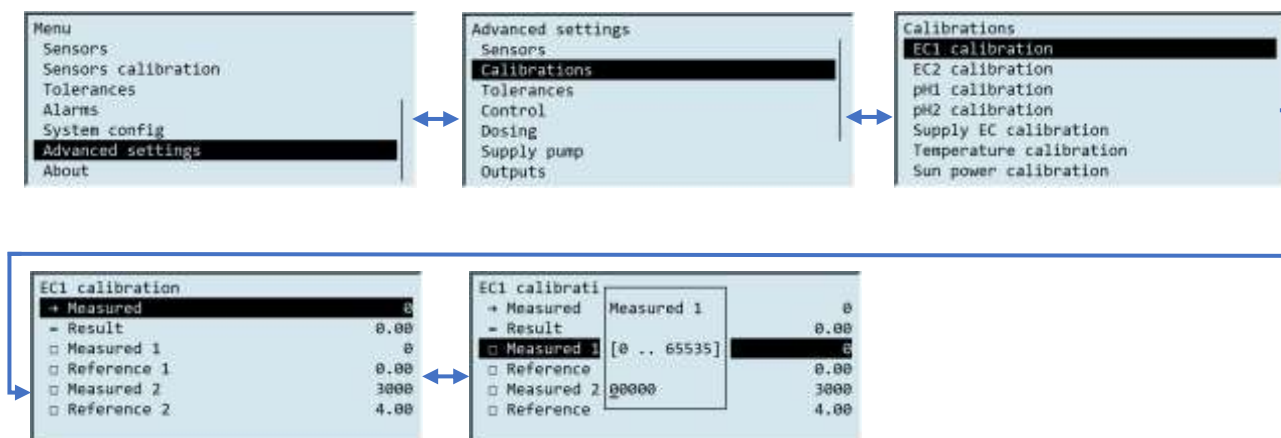


5. Sensor calibration

Calibration mode is used to correct the factory setting during operation. Calculate the linear dependence of the measured value on the sensor output signal and store the calculated coefficients, when calibrating from the controller's panel using two calibration points. Calculate the value of the measured parameter indicated on the display and use for control, during operation according to the stored coefficients in proportion to the measured digital signal. The measuring sensor readings should be checked regularly with control devices.

Note! New settings are additionally stored to nonvolatile memory (EEPROM) and are retained regardless of the battery status, when calibrating sensors. After long shutdowns by pressing the "TEST" button or by power failure of the computer, the calibration values are automatically restored.

*The sensors are calibrated by moving the cursor in the main menu to the line **Advanced settings / Calibrations**:*



6.1 Initial calibration of EC sensor.

Calibrate the EC sensors, when starting the system for the first time and after cleaning the EC sensors:



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EC sensors measure the salt content of a solution by means of conductivity (1 mS / cm), that corresponds to 1000 ohms of electrical resistance per centimeter. EC sensors are calibrated from the controller. For calibration is required one calibration solution.

EC sensor calibration:

1. Select the «Calibration EC1/2» screen frame in the controller menu.
2. Release the sensor from the fasteners (unscrew counterclockwise).
3. Remove the sensor and clean the electrodes from deposits with a napkin.
4. Press “Enter” button in the “Measured 1” line and enter from the keyboard a value equal to the value from the "Measured" line, enter the value = 0 mS / cm in the "Standard 1" line.
5. Place in a vessel with a calibration solution with an EC close to the value set during watering. (For example, 1.41 mS / cm if the watering target is close to this value).
6. When placing the sensor in the calibration solution, the sensor body should not touch the walls and bottom of the vessel.
7. Wait 1-2 minutes for the sensor readings to stabilize.
8. Press “Enter” button in the “Measured 2” line and enter from the keyboard a value from the "Measured" line, enter the current calibration solution value in the "Standard 2" line.
9. The “Result” line displays the value of the current calibration solution to verify values are accepted. Otherwise, it is necessary to verify that the solution have the given conductivity with a portable conductivity meter.
10. Install the sensor in its original place and secure with fasteners (tighten clockwise).
11. Verify with a portable conductivity meter that the calibration was successful and that the conductivity irrigation is satisfactory, when starting watering for the first time after a calibration.

6.2 Initial calibration of pH sensor.

pH acidity sensors have an average service life of 1.5 years. This is a lamp made of glass that transmits hydrogen ions with ultrasonic electrodes. The electrodes measure the change in the composition of the lamp gaseous medium. Thus, they have limited life span and don't allow depressurization. pH sensors are calibrated from the controller. For calibration two calibration solutions are required.

Calibration pH sensor:

1. Select the «Calibration pH1/2» screen frame in the controller menu.
2. Release the sensor from the fasteners (unscrew counterclockwise).
3. Remove the sensor and wash with distilled water. Place in a vessel with a calibration solution with pH from 3 up to 5.
4. Release the pH wire from the fasteners (in case if a system has one. Unscrew counterclockwise)
5. Ground solution and place pH wire into solution. (in case if a system has one).
6. Wait 1-2 minutes for the sensor readings to stabilize.



7. Press "Enter" button in the "Measured 1" line and enter from the keyboard a value equals the value from the "Measured" line, enter the current calibration solution value in the "Standard 1" line.

8. The "Result" line displays the value of the current calibration solution to verify values are accepted. Otherwise, it is necessary to verify that the solution have the given acidity with a portable pH meter.

9. Wash the sensor with distilled water. Place in the second vessel with a calibration solution with pH from 7 up to 10.

10. Ground solution and place pH wire into solution. (in case if a system has one).

11. Wait 1-2 minutes for the sensor readings to stabilize.

12. Press "Enter" button in the "Measured 2" line and enter from the keyboard a value equals the value from the "Measured" line, enter the current calibration solution value in the "Standard 2" line.

13. The "Result" line displays the value of the current calibration solution to verify values are accepted. Otherwise, it is necessary to verify that the solution have the given acidity with a portable pH meter.

14. Install the sensor in its original place and secure with fasteners (tighten clockwise).

15. Fasten pH wire (tighten clockwise).

16. Verify with a portable pH meter that the calibration was successful and that the acidity irrigation is satisfactory, when starting watering for the first time after a calibration.

6. MONITOR software. Main functions.

Setting, displaying, archiving data is carried out by means of the "MONITOR" program.

6.1 Program use

The MONITOR program (MONITOR) is designed to operate with microclimate and irrigation control devices in industrial greenhouses, as well as for communication with devices for measuring plant parameters (phytomonitoring).

The connection of devices with the MONITOR program is carried out using a USB - RS485 interface converter, as well as an Ethernet interface. Recommended number of devices for connection up to 10.

6.2 Main controls

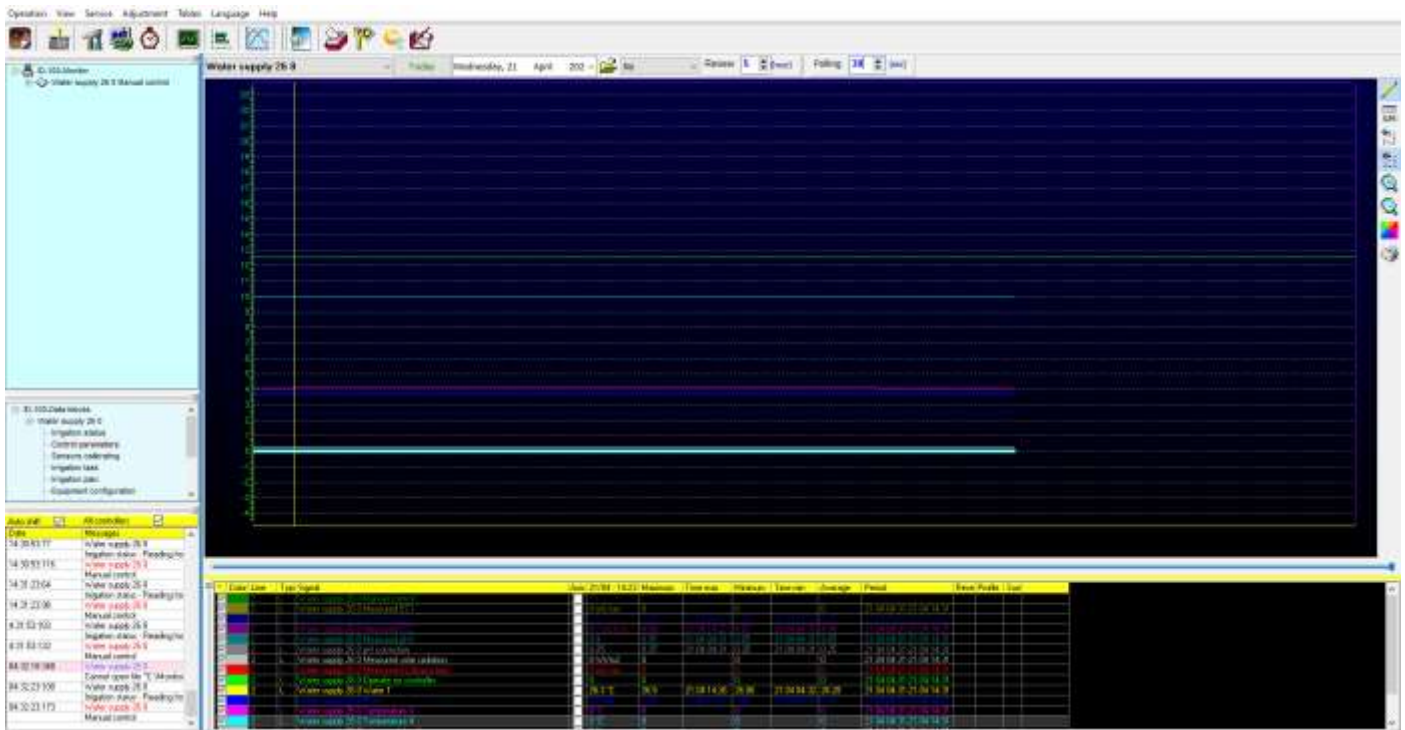
Program main window (main form) is shown in the Picture 1.



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Picture 1

In the central part of the screen there is a graph display area. Below it is a legend (area for configuring display parameters). You can select here which of the listed graphs to display. For each graph can be set its own parameters at the same time :

- Graph color
- Line thickness
- Scale (two), axis
- The type of signal change formation (either a stepwise change from point to point, or connection of the points of the graph with straight lines)

It is possible to combine several graphs with different measurement axes. Mark the desired graph with a tick in the "Axis" field for this.

The following buttons are available to navigate through the forms:



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- 1- Show status (mnemonic diagram)
- 2- Controller type (the parameters of communication with the controller)
- 3- Control parameters (control parameter table)
- 4- Calibrations (calibration table)
- 5- Task per day (to control irrigation and microclimate system)
- 6- Archives from files on disk (archives of table records)
- 7- Analyzer parameters
- 8- Archive graphs (an additional window in which you can display graphs from archived records)
- 9- Voice selection and parameters (voice assistant options)
- 10- View logs
- 11- Date of graphs displayed in the main form
- 12- View interval (from 1 up to 24 hours), the frequency of data receiving (from 5 up to 300 sec.)

7.3 Connection with MONITOR program

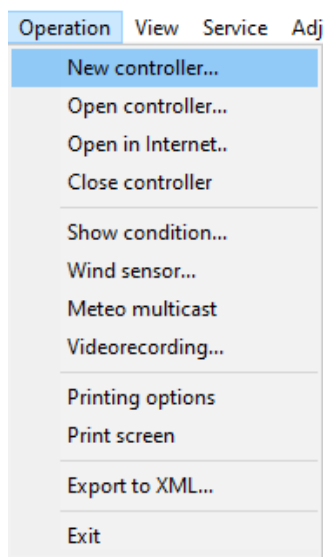
Connection setup:

1) The controller and PC must be connected to one local network according to the principles of forming local networks for a group of PCs.

2) Set a static IP address on the PC in the "Properties" field of the local network:

Controller IP address "**IP address :192.168.001. ____**" serves to establish connection according to the principles of PC local networks. IP address must be unique on a given subnetwork. The subnetwork must not be null.

To establish connection between your device and MONITOR program select in the "Menu" [Actions → New controller), [picture 3]



Picture 3

Set the parameters of connection with the controller in the opened window [picture 4]:

1. Data port is set according to the number of the RS-485 - USB interface converter COM-port, to which the device is connected via the RS-485 interface. It is not necessary to set it for the connection system via ETHERNET.

2. Controller number. Don't set it for the connection system via ETHERNET.

3. IP address is set according to the controller IP address.

4. Controller type is selected automatically

5. Description:

xml allows to correct individual blocks / codes / keys / tables

bin does not allow controlling.

In other words, **bin** is used for the user / operator and **xml** is used by a specialist to make adjustments to MONITOR program.

6. Controller. Set any controller identifier (It must be unique for given PC).



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New controller ✕

Connection parameters		Controller type	
Port for data transmitting	<input type="text"/>	Water supply 26	26
Controller number	0	Modification	8
IP address	192.168.1.211:8000	Quantity of misting valves	0
		Quantity of irrigation valves	40
		Quantity of batchers (including pH)	5
<input checked="" type="checkbox"/> Connect		Description <input type="radio"/> xml <input checked="" type="radio"/> bin	

Data source:

Controller	Water supply 26 0	<input checked="" type="checkbox"/> Create	<input checked="" type="checkbox"/> Cancel
Alias	<input type="text"/>		

Picture 4

Set the IP address of the controller (Controller type, modification parameters are determined automatically). Click the "Connection" button, set a new controller identifier in the "Controller" line and press "Create".



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If an error message appears, check the connection with the controller. [picture 5]

New controller ✕

Connection parameters

Port for data transmitting

Controller number

IP address

☒ Connect

Timeout

Controller type

Modification

Quantity of misting valves

Quantity of irrigation valves

Quantity of batchers (including pH)

Description

☐ xml ☒ bin

1. Check the connection to the controller
2. Set the correct number of controller
3. Select the correct number of COM-port

Controller

Alias

☒ Create ☒ Cancel

Picture 5

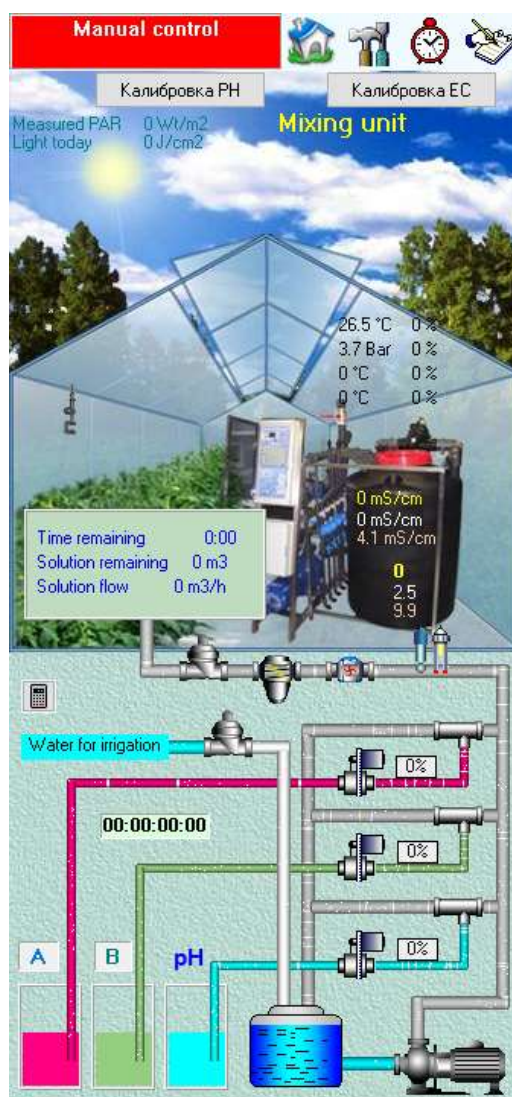
After creating a new controller, a "mnemonic diagram" will appear [picture 6]. The controller will appear under the given name in the "Controller drivers" window (upper left corner) [picture 7].



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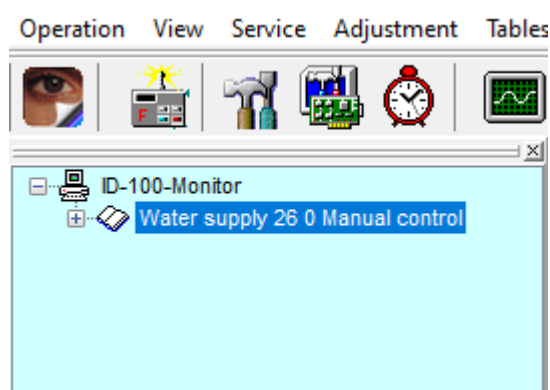
Picture 6



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Picture 7

When the controller is created, you can configure and control the microclimate and irrigation system using various control elements.

6.4 Date and time setting.

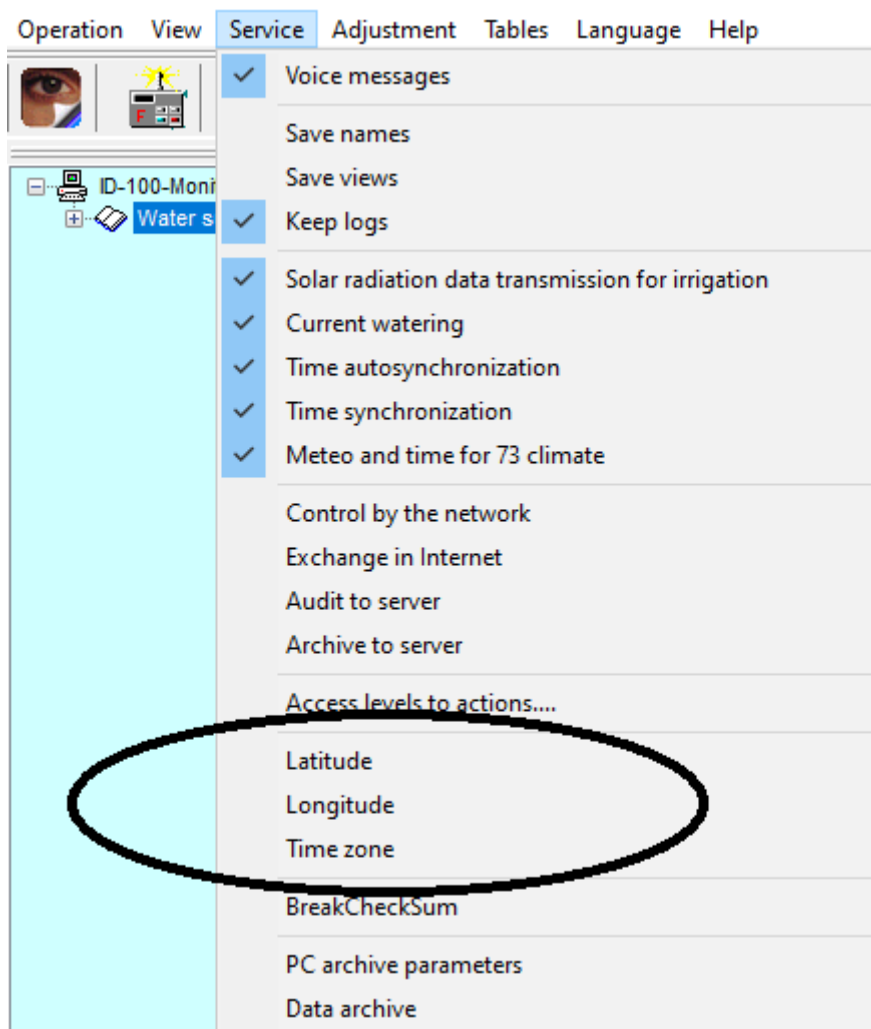
Set in MONITOR program installed on the main computer the latitude and longitude of the greenhouse location, as well as the time zone in the “Service” program window in order to calculate correctly the time of sunrise and sunset. (Picture 8).



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Picture 8 "Service", MONITOR program

Note.

The time and the calendar are controlled by a separate microcircuit. Therefore, with the installed battery power, the time is calculated even with the power off of the main computer. When the controller is switched on, the time in the controller is periodically synchronized with the system time in the main PC.



7. Safety measures

When working with the controller, the safety measures correspond to the measures of working with general radio equipment. The maximum voltage in the electronic unit is 220V, in the power unit is 380V. The adjustment and maintenance of the device must be carried out by qualified specialists who have safety training.

8. System operation

The electronic control unit should be installed in a dry and shaded place.

Recommended environmental conditions:

- temperature 20-25 ° C
- relative humidity 60-70%.

Long exposure of direct sunlight to the LCD of your PC is not recommended. Power the control unit by a network to which no high-current equipment is connected. Do not place it near powerful sources of electromagnetic interference. Don't increase the ambient temperature above + 60 ° C during operation and storage due to malfunction of the liquid crystal display.

8.1 Daily system maintenance:

a. Power supply and controller.

- 1) Check for power supply to the controller.
- 2) Check for 3-phase power supply 380V in the power unit.
- 3) Check the circuit breaker position of the system.
- 4) Check the control cables and the mechanisms.

b. Water supply.

- 1) Check for water at the system inlet.
- 2) Check that the water pressure at the system inlet is 4-6 kg / cm.
- 3) Make sure that the water supply matches the irrigation pump capacity (not less). [See pump label]
- 4) Check that the handles of all taps, vents and valves in the system are in the correct position. [See the irrigation system scheme].
- 5) Check and, if it necessary, wash all filters.
- 6) Make sure there are no leaks in the lines.

c. Hydraulics and fertilization

- 1) Check a properly prepared acid solution in the PH tank.



2) Check properly prepared nutrient solutions.

3) Check all lines and the position of the nutrient solution valves. If there is an uneven flow of nutrient solutions, you should wash the nutrient solution filters, clean the nutrient solution supply lines and adjust the opening of the supply valves.

d. Sensors

- 1) Check and calibrate EC sensors, if it is necessary.
- 2) Check and calibrate pH sensors, if it is necessary.
- 3) Check and calibrate Temperature sensors, if it is necessary.
- 4) Check and calibrate solar radiation sensors, if it is necessary.

e. Controller setting

- 1) Make sure the controller clock is showing the correct date and time.
- 2) Check if the irrigation plan and watering task are set correctly.
- 3) Set the necessary tolerances for the alarm activation and the parameters of retry after the alarm in the menu "Tolerances".
- 4). Check the operation of all mechanisms in manual mode:
pumps (rotation in the direction of the arrow),
solenoid valves for irrigation and fertilizer dosing,
the correct signals from the level sensors in the mixer and in the water storage tank.
- 5) After a complete check of the equipment, set the "Watering task". To start watering by task, manual control must be switched off.

8.2 Preventive system maintenance:

Clean the irrigation unit fine filter regularly. The washing frequency is determined by the quality of the water used. The filter must be washed if the difference in the readings of the control pressure gauges at the inlet and at the outlet of the filter exceeds 0.5 kgf / cm² or, the current flow rate of the solution has decreased by 10% of the calculated one according to the computer readings.

Flush the sand and gravel filter if it is installed with reverse water flow.

Check nutrient solution lines. If there is an uneven flow of nutrient solution, you should wash the nutrient solution filters, clean the nutrient solution supply lines and check the opening of the supply valves.

Check the readings of the EC sensors by the control device. If it is necessary, calibrate the sensors. Wash the sensors if there is a large difference in readings.

Check the readings of the pH sensors by the control device. If it is necessary, calibrate the sensors. Note that the pH electrodes become dirty over time, wear out and require recalibration.

Perform the prevention of the pH electrode if there is a large discrepancy in the readings.

See instructions below:



The pH electrode is removed after unscrewing the protective cap. When installing, the pH electrode is carefully lowered to the stop and is fixed by means a protective cap in this position without using a tool.

9. Instructions for using pH sensors

1. Store the pH electrode in an upright position in a plastic container between measurements, make sure that the sensitive element of the electrode is immersed in the solution filling the container. You can use a molar solution 3 of potassium chloride with a drop of hydrochloric acid so that the pH of the solution is in the range of 3-4 units.

2. After removing the pH electrode from the measured or buffer solution, shake it sharply, wash it with distilled water and shake it again to remove liquid drops. This reduces errors in next measurements, which may arise due to contamination of the measured solution with traces of solutions from previous measurements.

3. Calibrate the electrode in buffer solutions with pH values close to the working ones. This will also reduce measurement errors.

4. Make sure that the temperatures of the solutions during calibration and during measurements differ by no more than 5 ° C, or use the temperature compensation mode.

5. The time for potential establishing (response time) can be different in different solutions. Usually, the time in buffer solutions is shorter than in measured ones and can even be several seconds, while it may even take several minutes for the electrode potential to stop changing in measured solutions.

6. Note. The pH electrode has a limited life span. In fact, its resource starts to consume from the moment of manufacture, regardless of whether you are taking measurements or simply storing it. Try to make the most of this resource.

You can see the pH electrode wear out as a decrease in the measuring range (or electrode slope) and in an increase in the electrode response time.

If you notice these effects during operation, clean or condition the electrode in accordance with the following items of this manual. If conditioning does not improve performance, the pH electrode should be replaced.

9.1 Cleaning the electrode:

On the sensing element of the pH electrode can form various compounds from the measured solutions, which can lead to incorrect measurements, including a decrease in the slope of the electrode characteristic. Different cleaning methods are used depending on contamination. The simplest method is used to remove water soluble compounds. In this case, intensive stirring in distilled water is sufficient. Organic and chemical contaminants are removed chemically. However, the choice of a chemical cleaning method should be approached very carefully, having in mind that an incorrectly applied method can lead to electrode damage.



9.2 Conditioning the electrode:

The upper layer of the pH electrode surface glass sensitive element is etched away and the activity of the electrode is restored.

Note that this method does not always guarantee electrode function restoration, but in some cases it is quite effective.

Have in mind that the reagents used for conditioning are highly corrosive and toxic and can only be used by qualified specialists observing the necessary precautions.

1. Immerse the glass tip of the pH electrode in 0.1 N HCl solution for 15 seconds. Wash with water, place the tip for 15 minutes in 0.1 N NaOH solution and wash with water again. Repeat this procedure three times and then check the electrode. If the electrode is not restored, try the following procedures in item 2.

2. Immerse the glass tip of the pH electrode in NH₄F.HF solution 20% (ammonium bifluoride) for 2-3 minutes. Wash with water and check the electrode. If the electrode is not restored, try the following procedures in item 3.

3. Immerse the glass tip of the pH electrode in HF solution 5% for 10-15 seconds. Wash carefully with water, immerse the glass tip of the pH electrode in 5 N HCl solution for a short time. Wash carefully with water and check the electrode.

If the electrode is not restored, then it's time to get a new electrode.

10. Frequently asked questions about the operation of the irrigation unit

Question: What needs to be done when starting the irrigation unit for the first time?

Reply: Make sure that the handles of all taps, vents and valves in the system are in the correct position (See the irrigation system scheme).

Check and calibrate EC and PH sensors, if it is necessary.

Verify "Watering plan" and "System settings" are set correctly. Set the necessary tolerances for the alarm activation and the parameters of retry after the failure in the menu "Tolerances".

Then, it is necessary to check manual the operation of all mechanisms: pumps (rotation according to the arrow), solenoid valves for irrigation and dosing, as well as the correct signals from the level sensors in the mixer and the water storage tank. After a complete check of the equipment, enter the Watering task. To start watering manual control must be disabled.

Question: What if the irrigation unit stops watering?

Reply: It is necessary to find out the reason for the irrigation unit stop. As a rule, it is enough to view the status of the irrigation system in the bottom line of any screen frame. This line indicates the cause of the alarm in the event of an alarm.



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If irrigation is stopped due to the solution parameter out of the set tolerance, the name of the solution parameter (EC, PH, T) that is out of the set tolerance, is displayed.

If the nutrient solution flow rate doesn't correspond to the set limits during the control time, the "Flow failure" appears.

If the watering is to be carried out, but there is no water in the mixer, the second line says "No water".

If there is no water at the water pump inlet and the irrigation unit tank is empty, the computer reports on the screen "Water pump failure".

The automated system is disabled in manual control status and watering task doesn't work. To start or continue watering by task, you must turn off the manual control.

Question: What if the irrigation unit stops and the "Flow failure" appears?

Reply: This means that the flow rate of the nutrient solution (the flow rate speed) doesn't correspond to the set limits during the control time. This could be due to incorrect dripper capacity and plant counts for the irrigation valve set in the "Watering plan", or a narrow tolerance range. If the values in the "Watering plan" are set correctly, you should check the irrigation network for solution leaks. You should check the position of the valves and the opening of the irrigation solenoid valves as well.

Question: What if the solution unit stops and the "EC / pH failure" appears?

Reply: This means that watering has been stopped due to the solution parameter out of the set tolerance. Check the operation of the dosing valves (A, B, C, D and pH) in manual mode. Make sure that the dosing valves are working properly, check if the nutrient solution prepared correctly in the tanks according to the agronomic recipe. Then check the position of the valves on the nutrient solution tanks and the tightness of the piping from the nutrient solution tanks to the dosing valves.