

Instruction Manual

HI 8001 & HI 8002 Panel-mounted and Wall-mounted Fertigation Controllers

AGRICARE

Dear Customer,

Thank you for choosing a Hanna Product. Please read this instruction manual carefully before using the instrument.

This manual will provide you with the necessary information for a correct use of the instrument, as well as a precise idea of its versatility.

If you need more technical information, do not hesitate to e-mail us at techserv@hannacan.com.

These instruments are in compliance with **CE** directives.

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1 THEORY OF FUNCTION

Irrigation is one of the most important operation in agriculture. With proper irrigation the quality and quantity of crops can be significantly enhanced. Correct irrigation is not a simple process: the quantity of water must be sufficient for crops, and if not, photosynthesis and overall growth is impeded. However, if the amount of water is more than required, plant growth may become excessive producing a taller, softer and/or damaged product.

The Fertigation Controller can control the quantity of irrigation water based on time or volume. Different sectors can be irrigated at different times during a day with different water quantities.

In the Fertigation Controller each irrigation program provides control of pH and conductivity. When necessary, a specific program performs a pH correction by the introduction of an acid or base into the irrigation water. pH control is based on multiple sensor input and a specified set point, while conductivity control is directly related to the level of fertilization.

When the Fertigation Controller commands the addition of 1 to multiple fertilizers to the irrigation stream, conductivity sensors continually monitor the conductivity of the stream and the overall amount of fertilization is maintained based on a specified set point (limit). The Fertigation Controller can command the addition of multiple (1 to 4) fertilizers to irrigation water. The percentage of each fertilizer is set by the user and controlled by a specific program based on the conductivity set point.

If a pH or conductivity control problem arises, the program generates an alarm to inform the user. All operations of both control processes are stored in memory.

The Fertigation Controller performs all necessary operations in the monitoring and control of irrigation and fertilization processes. These operations are conducted continuously throughout the day, month and year. To use and manage the system properly, all the necessary control values must be set (Setup mode). During monitoring operations (Consulting mode) the user can obtain information about how the system and irrigation process are functioning, in addition to the history of all operations for current and previous days. To view the required information on the display or set a specific parameter, the appropriate display panel has to be selected, as explained in this manual.

2 GENERAL DESCRIPTION

The Fertigation Controller is a micro-processor-based system used in fertilization and irrigation control for greenhouses or open fields with powerful, flexible programming features.

The main function of the Fertigation Controller is supplying and controlling the necessary water and fertilizers for crops according to several parameters such as acidity, conductivity and received solar radiation.

The user interface is structured in two parts:

1. Consulting (numbered panels indicated by Cxx)
2. Setting (numbered panels indicated by Sxx).

This instruction manual will present the interface in 2 forms:

1. Fertigation Controller functions
2. Panel order

Fertigation Controller is capable of executing the following functions:

- Irrigation control by time or by volume
- pH control
- Conductivity control
- Fertilization control
- Irrigation adjustment due to solar radiation
- Manual correction
- Agitator control
- Filter control
- Water supply control
- Main pump control
- Sector control
- Serial communication
- Alarm function
- Logging function

3 FUNCTION DESCRIPTION

In this chapter the main functions of the Fertigation Controller are presented. For a better understanding see the typical installation schemes utilized for irrigation and fertilization presented in the Installation Block Diagram, Appendix 5.

3.1 IRRIGATION CONTROL

The Fertigation Controller can control 8 to 32 sectors (one valve per sector) for each of the ten irrigation programs:

- 1 to 32 valves (sectors) can be selected specifying the sector's number and the desired value of irrigation time or volume for a specified irrigation program-using Panel S 38 (SET SECTORS). The panel displays the number of set sectors for the respective irrigation program
- The current status, set value plus irrigation extension and "Done" time/volume value for the selected irrigation program/sector are shown on Panel C 14 (SECTOR STATE).

Irrigation can be controlled by time or volume – irrigation control mode can be switched between time and volume using panel S 53 (IRRIG CTRL MODE).

Each irrigation program can be started by:

TIME:

- 1 to 6 different timetables (values) per program can be set using panel S 35 (SET START TIME). "Start cond" must be the selected option on panel S 34 (START CONDITION).

ACCUMULATED SOLAR RADIATION:

- A Solar Radiation set point can be established for starting each program
- The accumulated solar radiation level can be used as a starting condition for each program
- There are 3 parameters used to start a program by solar radiation:
- The solar radiation sensor threshold value can be established for each irrigation program. When the solar radiation measured value exceeds the sensor threshold value the accumulated solar radiation value is increased. This parameter can be modified on panel S 43 (Level: xxxW/m^2).
- The accumulated solar radiation value is used to keep track of the measured solar radiation level during the time interval determined by the previous start moment of the irrigation program and the actual moment. This parameter can be seen on panel S 06 (Irrig = xxxWh/m^2).

- The accumulated solar radiation starting level value is used as a threshold value for the accumulated solar radiation. When the accumulated solar radiation value exceeds this threshold level the irrigation program is started (or it is brought in READY state if there are other programs currently running at that moment). This parameter can be modified on panel S 43 (Acc = xxx Wh/m²) and can be seen also on panel C 06 (Acc = xxxWh/m²)

EXTERNAL TANK LEVEL:

- One external tank (level indication) can be assigned to each irrigation program, that can start the specified irrigation program – this option is set using panel S 34 (START CONDITION).

MANUAL ACTIVATION:

- A program can be started using panel S 47 (PROG MAN START)
- A program can be stopped using panel S 48 (PROG MAN STOP)

Each irrigation program can be repeated a specified number of times. The number of repetitions as well as pause time between two repetitions can be specified using panel S 36 (PROGRAM REPEATS).

Each irrigation program can be given a priority in relation to others (5 priority levels). Priorities and maximum open sectors per group can be specified for each program and can be set using panel S 33 (SET PRIORITY).

Below we present the setting requirements for each irrigation program:

THE WORKING PERIOD :

- (between start date (day/month) and end date (day/month)) – use panel S 31 (ACTIVE TIMETABLE). For more details see Appendix 3.

THE WORKING TIME DURING A DAY:

- (between start time and end time) – use panel S 31 (ACTIVE TIMETABLE). For more details see Appendix 3.

THE CYCLE WORK/ REST DAY:

- can be set using panel S 32 (WORKDAY). For more details see Appendix 3.

THE WORKING DAYS IN A WEEK:

- use panel S 32 (WORKDAY). For more details see Appendix 3.

Working time status for each irrigation program, if selected (irrigation program is in work period of year, day and week) is displayed in panel C 08 (WORK TIME COND).

The percent of irrigation time or set volume can be automatically modified by the following factors:

SOLAR RADIATION FACTOR:

- This option can be set using panel S 42 (CORRECTIONS). This factor affects the irrigation time or volume extension in accordance with the set value of the solar radiation sensor level and solar radiation accumulation. The solar radiation accumulation extension setting and current value is displayed on panel C 06 (SOLAR RAD IRRIG). Solar radiation extension correction can be viewed using panel C 11 (SOL RAD EXTENT).

MANUAL FACTOR:

- This option can be set using panel S 42 (CORRECTIONS). Percentage and corresponding value of time or volume can be viewed using panel C 12 (MAN FACTOR).

Total correction percentage, time or volume value is displayed on panel C 13 (TOTAL CORRECTION).

PRE/POST IRRIGATION:

In each irrigation program the pre-irrigation and post-irrigation time or volume value (used to clean the irrigation pipes with pre-irrigation water) can be set using panel S 37 (PRE/POST IRRIG).

Panel C 01 (GENERAL INFO) displays the active irrigation program and active sectors.

The active irrigation program is displayed on panel C 02 (SENSORS STATE).

Related data regarding the active irrigation program (active irrigation program number, last start condition and current / set repetition number) are displayed on panel C 03 (PROGRAM STATE).

Information about selected irrigation program, priority and irrigation program conflict are displayed on panel C 09 (PRIOR & CONFLICTS). Set value data, correction value and irrigation completion ("Done") value are displayed on panel C 10 (IRRIG STATE).

Information about the last start condition, date and time are displayed on panel C 18 (PROG LAST START).

Total accumulation value from a previous date is displayed on panel C 19 (TOTAL ACCUMUL).

Accumulation value from previous date and activation number for a selected irrigation program are displayed on panel C 20 (PROGRAM ACCUMUL).

Accumulation value from previous date, for a selected sector, is displayed on panel C 21 (SECTOR ACCUMUL). In addition, this panel displays the valve number assigned with the corresponding sector.

- Accumulations erase mode can be chosen on panel S 61 (ERASE STATISTICS). The accumulation erase can be performed for all programs and

sectors using one of the following ways:

- Manually
- Every day at specified hour
- Automatically when the accumulations counter value overflows

3.2 CONDUCTIVITY CONTROL

Conductivity control is used to control the fertilization and a reading can be obtained with one to three conductivity sensors, one to two for fertilization control and one for water supply conductivity control.

When using two conductivity sensors, the second for safety, the maximal admissible difference between these two sensors can be set using panel S 55 (SENSORS CONFIG).

A third conductivity sensor can be used to measure the conductivity of the water supply.

Conductivity sensor (S1 main, S2 second and S-for water input) status and conductivity reference are displayed on panel C 05 (EC STATE). In addition, the main conductivity sensor value is displayed on panels C 01 (GENERAL INFO) and C 02 (SENSORS STATE);

Solar radiation accumulation setting and current value for conductivity reference correction is displayed on panel C 07 (SOLAR RAD FERT).

The conductivity control is made in accordance with a preset conductivity reference value, specific for each irrigation program. In addition, the conductivity reference has a minimum offset and maximum offset. The reference value, minimum and maximum offset can be set using panel S 41 (COND CONTROL).

When the conductivity is not within the specified range for a period of time (more than the time specified) or the difference between the 2 primary conductivity sensors is greater than the specified difference, the conductivity control will generate a conductivity alarm . Specified difference can be set using panel S 55 (SENSORS CONFIG). The conductivity alarm threshold can be set using panel S 41 (COND CONTROL). "EC Out of Range"-the conductivity alarm can also be generated when the EC IN sensor's value exceeds the specified EC sensor difference.

Given a conductivity alarm condition, conductivity control can be maintained if "Ctrl on EC alarm" is selected using panel number S 52 (ALARM BEHAVIOR).

Statistical values of total conductivity are displayed on panel C 22 (TOTAL AVERAGES). For each irrigation program's conductivity average see panel C 23 (PROGRAM AVERAGES) and for each individual sector's conductivity average see panel C 24 (SECTOR AVERAGES).

3.3 FERTILIZATION CONTROL

Fertigation Controller can use up to 4 fertilizer tanks.

Each irrigation program can specify the percentage for each type of fertilizer. These values can be set using panel S 39 (SET FERTILIZERS).

The fertilization is done in accordance with the conductivity control. Each irrigation program has a specified conductivity target value (conductivity reference value which is set using panel S 41 (COND CONTROL);

The percent of applied fertilization can be automatically modified with respect to an amount of solar energy accumulated since the previous application. The current fertilizer status (set and current percentage value) can be checked on panel C 16 (FERTILIZ STATE).

3.4 pH CONTROL

The pH control is necessary to correct and maintain the pH of irrigation water within specified values (min and max offset values). Minimum and maximum offset values are set using panel S 40 (pH CONTROL). To choose between acid or alkaline correction you must go to panel C 51 (pH CTRL OPTIONS). In this panel you can also select pH correction in pre/post irrigation.

The pH correction is made in accordance with a selected pH reference value specific for each irrigation program. This value can be set using panel S 40 (pH CONTROL).

pH control is made with two pH sensors for additional safety and accuracy. Current status of sensors (main and secondary) in addition to the reference value is displayed on panel C 04 (pH STATE).

Main pH sensor value is displayed on panel C 01 (GENERAL INFO) and C 02 (SENSORS STATE)

When the pH is not within the specified range for a period of time (more than the time specified) or the difference between the 2 pH sensors (main and secondary) is greater than the specified difference the pH control will generate a pH alarm. The specified difference can be set using panel S 55 (SENSORS CONFIG). The pH alarm threshold can be set using panel S 40 (PH CONTROL).

Given a pH alarm condition, the pH control can be maintained if "Ctrl on PH alarm" is selected using panel number S 52 (ALARM BEHAVIOR).

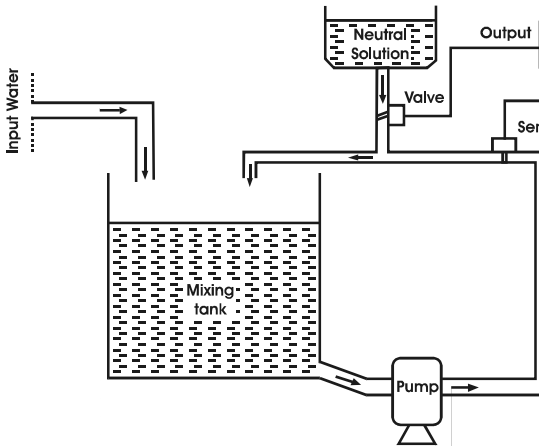
Given a pH alarm condition, the irrigation can be maintained if "Irrig on PH alarm" is selected using panel number S 52 (ALARM BEHAVIOR).

Statistical values of pH are displayed on panel C 22 (TOTAL AVERAGES). For each irrigation program's pH average see panel C 23 (PROGRAM AVER-

AGES). For each individual sector's pH average see panel C 24 (SECTOR AVERAGES). All pH averages can be deleted manually or at specified time of day using panel S 61 (ERASE STATISTICS).

3.5 PID CONTROL

A simplified schematic of the control (pH and EC):

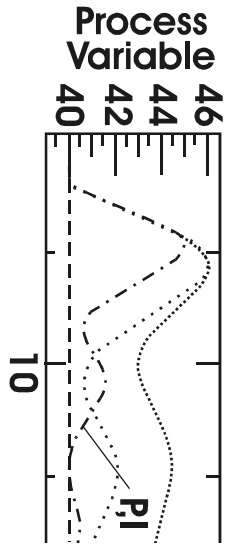
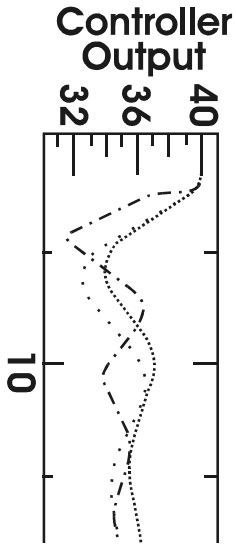


EC and pH control is performed using an automatic regulated system with PID controller (Proportional, Integral and Derivative). The role of this controller is to maintain a set pH and EC value within a mixing tank prior and during distribution (see diagram). The control of pH and EC is made separately.

The components are as follows:

- The mixing tank where the influent and additives are combined
- The neutral (additive) solution tank containing an acid, base or fertilizer
- The valve for introducing the additive solution into the mixing tank controlled by the PID controller
- PID Controller
- The input (influent) water source
- The pump for pumping water from the tank to the irrigation sectors

The Fertigation Controller automatically provides a command output signal to a control element such as a pump or valve based on a sensor input signal. The function of the Fertigation Controller is to proportionally control the pH and EC of the process at a specified set point. The above output signal commands the



opening and closing of a valve through which a neutral solution is circulated. The amount of neutral solution added is relative to the opening of the valve, which is directly proportional to the magnitude of difference between the mixing tank pH and the set point.

Control of pH implies a complex adjustment. The relation between the added reagent and the process pH is logarithmic. There is the possibility to introduce large errors in the process due to over dosing or under dosing reagent creating an oscillation effect. PID control can be used to reduce the possibility of overshoot and large oscillations in the process by creating control output proportional to the magnitude of deviation from the set point (P), time integral of error (I), and rate of change of the measurement (D). Proportional, Integral, and Derivative (PID) control can be used individually (typically Proportional control only) or in combination such as PI, PD or PID. How these control actions are used depends upon the requirements of the process.

Set point (reference value) is the desired value of the measurement. The error is defined as the difference between the set point and measurement:

$$\text{Error} = \text{Setpoint} - \text{Measurement}$$

The descriptions and definitions of the individual control actions are as follows:

PROPORTIONAL ACTION (P):

The simplest continuous control mode is proportional control, so called because the controller output is proportional to the magnitude of error. However, the proportional control is subject to one major limitation, steady state offset (steady deviation from the set point). Increasing the sensitivity of the controller (controller gain) can reduce the steady state offset but only with slow processes. For this reason the proportional control by itself it is used primarily for slow, consistent processes that can tolerate high controller gain, which minimizes the steady state offset. Consequently, high gain control action can throw the process into oscillation if the process variable becomes unstable and begins to change rapidly.

INTEGRAL ACTION (I):

To eliminate offset droop and tighten the control of the process, the integral action is introduced in conjunction with proportional control (PI). Integral control produces control action proportional to the time integral of the error. As long as the error exists (steady deviation from the set point), the integral term will continue to increase, adding more control action, driving the error toward zero.

DERIVATIVE ACTION (D):

With derivative action, the controller output is proportional to the rate of change of the measurement and is primarily used to avoid overshoots. Derivative action

can compensate for changes in the process variable (measurement) and is particularly good for slowly moving processes. When a change occurs in the process the derivative action causes the controller gain to move the “wrong” way until the measurement gets near the set point.

3.6 AGITATOR CONTROL

Each of the 4 fertilizer tanks may have an agitator.

An agitator can be activated in a specific tank prior to tank selection by an irrigation program. The pre-agitation time can be set using panel S 45 (SET AGITATORS); the pre-agitation occurs only when the pre-irrigation time is set.

During the irrigation program, the agitators can be stopped (if working time is zero), set to work continuously (if pause time is zero) and intermittently (if working time and pause is different than zero).

The work and pause time can be set using panel S 45 (SET AGITATORS).

The agitator settings are displayed on panel C 17 (AGITATOR STATE).

3.7 FILTER CONTROL

Fertigation Controller has the capability to check and automatically clean two filters controlled by two filter-cleaning programs.

Each filter cleaning program can be started by the following conditions:

- Following one specified irrigation program. This irrigation program can be set in panel S 46 (FILTERS CTRL).
- When a “dirty filter” alarm is activated. Cleaning by this option is set using panel S 46 (FILTERS CTRL).
- The working time for filter-cleaning programs can be set using panel S 46 (FILTERS CTRL).

3.8 MANUAL FUNCTIONS

The Fertigation Controller has the following Manual function capabilities:

- To switch the controller state between STOP, WORK and INIT, use panel S 49 (CONTROLLER STATE).
- The controller state can be checked using panel C 01 (GENERAL INFO).
- To manually start a program use panel S 47 (PROG MAN START).
- To manually stop a program use panel S 48 (PROG MAN STOP).
- To check and to change the value for each of the outputs, use panel S 50 (OUTLET MAN CTRL).

- To erase all statistics, use panel S 61 (ERASE STATISTICS). Statistics indicates pH and conductivity averages for all irrigation programs and sectors in addition to average total irrigation accumulation.
- To erase the settings of one irrigation program or to erase all settings for all irrigation programs, use panel S 62 (ERASE SETTINGS).

3.9 ALARMS

The Fertigation Controller has the capability to supervise and generate an alarm for the following conditions:

- Conductivity sensor out of range. Reference, minimal and maximal offset and threshold for conductivity alarm are set using panel S 41 (COND CONTROL). The current values of conductivity sensors are displayed on panel C 05 (EC STATE)
- A difference greater than the set value between the first and second conductivity sensors; Maximum value of difference is set using panel S 55 (SENSORS CONFIG)
- pH sensor out of range. The reference, minimum and maximum offset and threshold for pH alarm are set using panel S 40 (PH CONTROL). The current values of pH sensors are displayed on panel C 04 (pH STATE)
- A difference greater than the set value between pH sensors; the maximum difference value is set using panel S 55 (SENSORS CONFIG)
- Problems with the water supply
- Dirty filters

When the level is low in the fertilizer and acid tanks the system will take appropriate action and record the alarm. These actions can be:

- in case of a pH alarm condition, the irrigation process can be suspended or continued depending on the choice set within panel S 52 (ALARM BEHAVIOR) depending on the choice set within.
- in case of an EC alarm condition, the irrigation process can be suspended or continued depending on the choice set within panel S 52 (ALARM BEHAVIOR) depending on the choice set within.
- in case of a dirty filter alarm condition, start the filter cleaning program in accordance with the priority and working time settings
- in case of a water supply alarm situation, the Controller will stop every irrigation process until the alarm is shot off.

All alarm situations are displayed on panel C 25 (ALARM).

All anomalies (old alarm conditions) are displayed on panel C 27 (ANOMALY).

3.10 LOGGING FUNCTIONS

The Fertigation Controller has the capability to log the most important occurred events and values of different parameters that can offer a description of the evolution of the entire process;

The most important values are:

- Number and time period of every program activation;
- Filter cleaning;
- Averages of pH and conductivity;
- Accumulations;
- Modifications to preset fertilization values (e.g. manual, solar radiation);
- Alarms;

The logging level for recording and consulting can be set using panel S 59 (SET LOG LEVELS).

The date of desired logging records can be set using panel C 26 (VIEW LOG DATE).

The logging records are displayed on panel C 28 (LOG).

The selectable log recording/consulting levels range from 1 to 3. They are assigned as it follows:

Level 1: - records the sensors deviations events

Level 2: - records statistics (pH and EC averages, accumulations)

Level 3: - records programs and controller status events.

3.11 DATE AND TIME CONTROLLER SETTINGS

The controller date and time can be checked on panel C 01 (GENERAL INFO) and can be set using panel S 30 (SET DATE & TIME).

3.12 PASSWORD SETUP

The access to Fertigation Controller can be protected by a password. This password can be set using panel S 60 (SET PASSWORD), also this password can be disabled using the same panel.

4 USER INTERFACE

The Fertigation Controller's user interface consists of a 4 x 20 character LCD and a 23-key keyboard.



Keyboard structure.

4.1 OPERATING MODES

The Fertigation Controller operates primarily in two major modes:
Consulting Mode
Setting Mode

User interface panels (screens) are broken down into two categories:

1. CONSULTING PANELS
2. SETTING PANELS

Both modes of operation are readily available to the user.

1. CONSULTING MODE

The consulting mode allows the user to view the current state and set the conditions of the Fertigation Controller. The setting panels are in consulting mode until the SET key is pressed. The primary consulting screens are designated from C 01 through C 29. The following outline highlights the functions of the consulting mode.

- 2 browsing methods are enabled. See Section 4.2 "PANEL BROWSING METHODS".
- UP and DOWN ARROWS KEYS can be used to switch the panel index (where available) allowing user to view the same kind of data assigned to

different controller entities (programs, sectors, fertilizers etc.) within the same panel.

- LEFT and RIGHT ARROWS KEYS can be used to move the cursor within the selected parameter's limits.
- ESC key can be used as a shortcut key to access the C 03 (PROGRAM STATE) panel from any currently viewed panel.
- HOME key can be used as a shortcut key to access the C 01 (GENERAL INFO) panel from any currently viewed panel.
- END key can be used as a shortcut key to access the S 48 (PROG MAN STOP) panel from any currently viewed panel.
- TAB key can be used to switch the focus between the panel number object and the panels index parameter if the current panel is indexed. If there is no index parameter present on the current panel, the TAB key has no effect. Panels are typically indexed by the program number. For example, panel C 03 (PROGRAM STATE) displays the current state for each program. Once panel C 03 is selected and the TAB key pressed, the focus (cursor) is shifted from the panel number to the program number "Prog 01". The ARROW KEYS can now be used to scroll through each program state consecutively without leaving the panel.
- ENTER key is used to confirm any new values entered in any of the selected panels. This is only possible if data items on a panel (screen) are selectable.

2. SETTING MODE

The setting mode allows configuration of all the adjustable parameters of the Fertigation Controller. The setting screens are designated from S 30 to S 62. These panels can be viewed by one of 2 browsing methods. Selecting the appropriate screen and pressing the SET key initiates the setting mode. Once the setting mode is entered both panel-browsing methods are disabled and navigation is allowed only within the currently selected panel. The following outline highlights the functions of the Setting Mode.

- Both panel (screen) browsing methods are disabled. See Section 4.2 "PANEL BROWSING METHODS".
- Focus (cursor location) is automatically shifted to the first editable data object on the selected panel.
- UP, DOWN arrow keys allow navigation between all editable data objects within the current panel.

- LEFT, RIGHT arrow keys allow navigation within the currently focused data object. If the cursor exceeds the boundaries of the data object then the focus is transferred to the previous or next editable item within the current panel.
- TAB key can be used to move only in a forward direction, from one data object to the next within the selected panel.
- ENTER key confirms all the data entered in a current panel. Once the ENTER key is pressed and data confirmed, the controller reverts to consulting mode. The SET key must be pressed to reenter the setting mode.
- ESC key cancels new data entered in the currently focused data object and exits the setting mode. The change of data is not saved in the current object and the previous setting is maintained.

4.2 PANEL BROWSING METHODS

In consulting mode, two browsing methods are available to view each of the 62 panels (screens) of the Fertigation Controller.

- *Step-by-step browsing*: pressing the PAGE UP and PAGE DOWN keys allow consecutive navigation from one panel to the next. The direction is dependent upon which key is selected.
- *Direct access browsing*: the number of the desired panel can be entered directly using the panel number located on the bottom right corner of every panel, prefixed by a C or S. The panel number object is the initially focused object on each screen. After entering the value by using the keypad and ARROW KEYS, press the ENTER key to view the selected panel.

NOTE: If a panel is selected and the SET key is pressed entering the setting mode, both browsing methods are disabled.

4.3 PANEL LIST

PANEL TABLE

CONSULTING PANELS		SETTING PANELS	
01	GENERAL INFO	30	SET DATE & TIME
02	SENSORS STATE	31	ACTIVE TIMETABLE
03	PROGRAM STATE	32	WORKDAY
04	PH STATE	33	SET PRIORITY
05	EC STATE	34	START CONDITION
06	SOLAR RAD IRRIG	35	SET START TIME
07	-	36	PROGRAM REPEATS
08	WORK TIME COND	37	PRE / POST IRRIG
09	PRIOR & CONFLICTS	38	SET SECTORS
10	IRRIG STATE	39	SET FERTILIZERS

11	SOL RAD EXTENS	40	PH CONTROL
12	MAN CORRECTION	41	COND CONTROL
13	TOTAL CORRECTION	42	CORRECTIONS
14	SECTOR STATE	43	SOLAR RAD IRRIG
15	-	44	-
16	FERTILIZ STATE	45	SET AGITATORS
17	AGITATOR STATE	46	FILTERS CTRL
18	PROG LAST START	47	PROG MAN START
19	TOTAL ACCUMUL	48	PROG MAN STOP
20	PROGRAM ACCUMUL	49	CONTROLLER STATE
21	SECTOR ACCUMUL	50	OUTLET MAN CTRL
22	TOTAL AVERAGES	51	PH CTRL OPTIONS
23	PROGRAM AVERAGES	52	ALARM BEHAVIOR
24	SECTOR AVERAGES	53	IRRIG CTRL MODE
25	ALARM	54	CALIBRATE SENSOR
26	VIEW LOG DATE	55	SENSORS CONFIG

NOTE: Data that has been changed in an editable data object is saved once focus has been removed from that object by pressing the ARROW KEYS or TAB.

5 PANEL DESCRIPTION

5.1 GENERAL CONSULTING

The following panels C 01 through C 29 are for the general consulting of controller settings and current measurements. The data objects within each panel are described from left to right unless otherwise specified.

5.1.1 INITIALIZATION PANEL

```
HANNA  INSTRUMENTS
F1 CONTROLLER V0.90
      INITIALIZATION
Loading String Table
```

This panel is shown during the Fertigation Controller Initialization state; it contains the HANNA INSTRUMENTS logo, the name of the controller and the software version. The last line is used to display the current status of the initialization sequence. This panel is also used to display any possible errors that may occur during the start up sequence.

5.1.2 START PANEL

```
HANNA  INSTRUMENTS
      F1 CONTROLLER
Fri 15-03-2000 13:15
STOP          Press ENTER
```

5.1.3 INPUT PASSWORD PANEL

```
Enter password
****
```

This panel is displayed during the password authentication sequence. If this sequence fails, the user will be logged out and the START panel will be displayed. If the password is correct panel C 01 (GENERAL INFO) is displayed. The default password is 0000. See section 6.9.10 (Setting Password, S 60) for instructions on setting this feature.

Although access to the controllers features are denied, the functionality of the controller is not directly effected if a password authentication sequence fails.

5.1.4 GENERAL INFO – C 01

WORK	Anomalies	00
Prog 08	06.4pH	
Sect 07	02.1mS	13:15
GENERAL	INFO	C01

This panel displays the following information starting from top left:

Fertigation Controller Functional State (top left corner)

When the controller is running it can be in one of the following states: *INITIALIZATION*, *STOP*, *WORK*, *BLOCK*. When the Fertigation Controller is first powered on the first state is *INITIALIZATION*. In this state the unit performs internal tests. In *STOP* state all programs are suspended. Under normal conditions the functional state is *WORK*. In the *WORK* state all irrigation and fertilization programs are executed. If an alarm occurs the Fertigation Controller enters the *BLOCK* state until the alarm condition is corrected. The user can customize the alarm management system behavior using setting panels S 40, S 41 (pH and EC CONTROL) and panel S 52 (ALARM BEHAVIOR).

Anomalies (top right corner)

The anomalies counter represents the number of alarms triggered since the last reset of the counter. This counter can be customized and cleared along with all system statistics via setting panel S 61 (ERASE STATISTICS).

Program Number

Reflects the selected program (can be selected only inside panel C 03). If no program is active a number is not visible.

pH sensor reading

Current (main) pH sensor reading.

Sector Numbers

All sectors assigned to the active program are displayed (cyclically) but only when an active program is running. If a program is not active the number is not visible.

EC sensor reading

Current (main) EC sensor reading.

System clock

If an alarm condition is present the time indication will also flash "ALARM" to alert the user.

NOTE:

- If the user is logged in and the operational mode is CONSULTING MODE, this panel can be accessed anytime and from any panel using the HOME key as a shortcut.
- The Real Time Clock, pH and EC sensors are always visible regardless of state.
- Whenever the Fertigation Controller is connected to a PC that runs the specific application of the fertigation controller on PC in "ON LINE" mode, this panel displays the label "PCCom" above the controller clock position. In this case the Fertigation Controller's keyboard is disabled until the connection is lost due to different reasons.

5.1.5 SENSORS STATE – C 02

Active Program:	04
06.3pH	1200W/m2
06.4mS	13:15
SENSORS STATE	C02

This panel provides an overview of the real time values of the system's main sensors. This panel contains the following information:

Active program number

Displays the number of the executing program. If no program is running a number is not displayed.

pH sensor reading

Solar Radiation sensor reading

EC sensor reading

System clock

5.2 CONSULTING PROGRAM SETTINGS

The following panels allow viewing the program setting of the Fertigation Controller. The program number can be changed only in C 03 with the UP and DOWN keys. In addition, the TAB key can be used only in C 03 to toggle the cursor (focus) between the panel number and the program number. The desired program number can then be entered directly by using the keypad.

5.2.1 PROGRAM STATE – C 03

PROG 08 ACTIVE
Started by Solar Rad
Repeat 02/05 13:15
PROGRAM STATE C03

The purpose of this panel is to allow the user to inspect the status and settings of a particular program. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Program State

During the lifetime of a program it cycles through several states. Each program is initially in *NO SET* state which means no settings have been applied to the program by the user. Once the settings have been applied the program is considered in *SET* state. Once a specific condition such as start time is met the program passes to *READY* state to await execution. Once the program reaches the highest priority and the start time is met, the program passes to *ACTIVE* state and executes. The program may be suspended and placed in *WAIT* state due to a higher priority program moving to *ACTIVE* state or a specific alarm condition triggering. When a program completes execution it is placed in *FINISHED* state. The cycle may be repeated and the program returned to ready state if the program repeats were specified after a set delay period.

Program Started by

Displays how the last program start was triggered. Programs can be started by a met time condition, solar radiation level, manual start, low level in external tank, or directly after the completion of another program. If the program is in *NO SET* (no settings applied to program) or in *SET* (settings applied but conditions not met) state, "Started by" is blank.

Repeat

Displays the current repetition followed by (/) the maximum number of the programmed repetitions.

System clock

REMINDER: In CONSULTING MODE the ESC key can be used as a short-cut key to access this panel from any panel.

5.2.2 PH STATE – C 04

Prog 08	Ref=06.4pH
S1=05.4PH	
S2=05.5PH	13:15
PH STATE	C04

The purpose of this panel is to allow the user to inspect the current pH reference point for a specific program and the real time pH sensor readings. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03).
See Section 5.2.

Ref = Reference or set point pH value for the specified program.

S1 = Real time value of pH sensor 1. This reading applies to the entire process and is not program specific.

S2 = Real time value of pH sensor 2. This reading applies to the entire process and is not program specific.

System clock

5.2.3 EC STATE – C 05

Prog 08	Ref=02.0mS
S1=02.0mS	SIn=03.2mS
S2=02.1mS	13:15
EC STATE	C05

The purpose of this panel is to allow the user to inspect the current EC reference point for a specific program and the real time EC sensor readings. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03).
See Section 5.2.

Ref = Reference or set point EC value for the specified program.

S1 = Real time value of EC sensor 1. This reading applies to the entire process and is not program specific.

S2 = Real time value of EC sensor 2. This reading applies to the entire process

and is not program specific.

S in = Real time value of EC input sensor. This is an option sensor input to measure the conductivity of the incoming water supply. This reading applies to the entire process and is not program specific.

System clock

5.2.4 SOLAR RAD IRRIG – C 06

```
Prog 08
Irrig=0720Wh/m2
Acc=0720Wh/m2 13:15
SOLAR RAD IRRIG C06
```

This panel displays the solar radiation irrigation settings. Due to the effects of solar radiation it may be necessary to augment (correct) the irrigation process accordingly. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Irrig = The set level of accumulated solar radiation used for irrigation correction. This is a set point. Radiation beyond this limit will trigger a correction to the irrigation process.

Acc = Real time value of accumulated solar radiation.

System clock

5.2.5 WORK TIME COND – C 08

```
Prog 08 Time Y
          Day Y
          Period Y 13:15
WORK TIME COND C08
```

The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Time

Indicates if the selected program is set to run on a time schedule.

Day

Indicates if the selected program is set to run on a daily schedule.

Period

Indicates if the selected program is set to run on a yearly schedule.

System clock

5.2.6 PRIOR & CONFLICTS – C 09

```
Prog 08 Priority 05
Conflict Programs 02
                13:15
PRIOR & CONFLICTS C09
```

This panel indicates the priority level of the indexed program. Priority settings play a roll in program execution when two or more programs have similar starting conditions. The priority for a given program can be set using panel S 33 (SET PRIORITY). The Conflict Programs counter displays cyclically all programs that are in conflict with the currently active program. Programs can be in conflict if their specific start and running conditions are synchronous. Given this scenario, the program that has the highest priority will become active.

The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03).
See Section 5.2.

Priority

Displays priority of indexed program.

Conflict Programs

Cyclically displays the program number of programs in conflict with the currently active program.

System clock

5.2.7 IRRIG STATE – C 10

```
Prog 08 IRRIG
Set 01:15:20+005:55
Done 00:45:10 13:15
IRRIG STATE C10
```

This panel displays the current irrigation state of the indexed program. Time or volume can control irrigation and the above panel displays the set value and the amount of irrigation currently completed. The mode of irrigation (time or volume) can be selected using panel S 53 (IRRIG CTRL MODE). The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Set

Displays the required (set) value of irrigation in time or volume.

Irrigation correction value

(number directly following the Set value)

Done

Displays the current point of irrigation in time or volume.

System clock

5.2.8 SOL RAD EXTENT – C 11

Prog 08
+010%
+00:05:55 13:15
SOL RAD EXTENT C11

This panel displays how much the programmed irrigation parameters are modified (extended) due to the effects of solar radiation. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Irrigation extension percentage

Displays the overall extension percentage of irrigation for the selected program due to solar radiation.

Irrigation extension value

Displays (in time or volume) the extension value of irrigation for the selected program due to solar radiation.

System clock

5.2.9 MAN CORRECTION – C 12

```
Prog 08
      +015%
      +00:05:55   13:15
MAN CORRECTION   C12
```

This panel displays how much the programmed irrigation parameters are manually modified (corrected). The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Irrigation extension percentage

Displays the overall extension percentage of irrigation for the selected program due to manual correction.

Irrigation extension value

Displays (in time or volume) the extension value of irrigation for the selected program due to manual correction.

System clock

5.2.10 TOTAL CORRECTION – C 13

```
Prog 08
      +035%
      +12:00:13   13:15
TOTAL CORRECTION C13
```

This panel displays how much the programmed irrigation parameters are modified due to both manual and solar radiation corrections. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Irrigation extension percentage

Displays the overall extension percentage for a selected program.

Irrigation extension value

Displays (time or volume) the total extension value of irrigation for the selected program.

System clock

5.2.11 SECTOR STATE – C 14

```
Prog 08      Sect 21/21
Set 00:10:30+009:45
Done 00:03:10   13:15
SECTOR STATE      C14
```

This panel displays the state of each sector. Each sector has an electro-valve. When a particular sector requires irrigation the electro-valve is opened for a specified period of time. *Valve number along with sector label (upper right corner of display) indexes this panel.* This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Sect

The first number displayed is the sector number followed by “/” the valve number assigned to that sector. This parameter indexes the sectors for this panel.

Set

Displays the set value in time or volume for the selected sector/valve of the indicated program.

Done

Displays the current point of irrigation in time or volume for the selected sector/valve of the indicated program.

System clock

NOTE: The sector’s label can be assigned as customized numeric “tags” for all the Fertigation Controller’s valves. Labels can be specified using panel S 38 (SET SECTORS). As default, the sector label will be identical to the corresponding valve number.

5.2.12 FERTILIZ STATE – C 16

```
Prog 02      Fert 02
      Set 40%
Current 20%   13:15
FERTILIZ STATE      C16
```

This panel displays the set and current amount of fertilizer used for a specific program. The Fertigation Controller controls the dosing of 4 fertilizers. In this panel the fertilizer number is used as the index, allowing inspection of the percent values for up to four fertilizer tanks involved in the selected irrigation program. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Fert

Represents the index for this panel. Fertilizer tank number. Each program can control 1 to 4 fertilizer tanks.

Set

The set percentage of one of four selected fertilizers to be dosed.

Current

The current consumed percentage of one of four selected fertilizers.

System clock

NOTE: The fertilizers percentage values can be specified using S 39 (SET FERTILIZERS).

5.2.13 AGITATOR STATE – C 17

Prog 08		
Work 00:03		WORK
Pause 00:02		13:15
AGITATOR STATE		C17

To each of the 4 fertilizer tanks an agitator can be assigned. The agitators can be activated before dosing of a fertilizer, during dosing, or intermittently throughout the program. See Section 3.6 *AGITATOR CONTROL* for more information. In this panel the agitator number is used as the index. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Work

The set working time value for the indexed agitator of the selected program.

Pause

The set pause time value for the indexed agitator of the selected program.

System clock

NOTE: The agitator's working time values can be specified using panel S 45 (SET AGITATORS).

5.2.14 PROG LAST START – C 18

```
Prog 08      Filter --  
Last start Manual  
At 28-08 18:32 13:15  
PROG LAST START C18
```

This panel displays the last start data for the indexed program, including the filter-cleaning programs. There are 2 filter-cleaning programs, one for each filter. The filter programs follow the indexed irrigation programs. For example, if the Fertigation Controller is equipped with 10 irrigation programs, "Prog" number 11 and 12 will be designated for the two filter cleaning programs on the above panel. In this case the first 10 program numbers will indicate the last start data for the irrigation process. Programs 11 and 12 will indicate the last start data for filter cleaning. The program number indexes this panel. This panel contains the following information:

Program Number

Reflects the selected program (can be selected only inside panel C 03).
See Section 5.2.

Filter

Filter number

Last Start

The last start trigger for the indexed program (irrigation or filter cleaning).

At

The time of the last start for the indexed program.

System clock

5.3 STATISTICS CONSULTING

5.3.1 TOTAL ACCUMUL – C 19

```
From: 09-26 13:37;12
0007654L
13:15
TOTAL ACCUMUL C19
```

This panel provides a total (in time or volume) of the entire irrigation process (all programs) from the reset time. All Fertigation Controller's statistics including accumulations can be erased (manually, daily at specified hour, on overflow) within panel S 61 (ERASE STATISTICS).

This panel contains the following information:

From

Time stamp indicating the beginning of the overall irrigation process.

Accumulation

Total accumulation in time or volume

System clock

5.3.2 PROGRAM ACCUMUL – C 20

```
From: 09-26 13:37;12
000:00:25 Prog 01
Activations 03 13:15
PROGRAM ACCUMUL C20
```

This panel provides a total (in time or volume) for each of the irrigation programs. The program number indexes this panel. This panel contains the following information:

From

Time stamp indicating the start of recording (statistics).

Accumulation

Total accumulation in time or volume for the indexed program.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Activations

The number of activations of the indexed program since the recording start.

System clock

5.3.3 SECTOR ACCUMUL – C 21

```
From: 09-26 13:37;12
000:00:17 Sect 01/01
13:15
SECTOR ACCUMUL C21
```

This panel provides a total (in time or volume) for each of the irrigation sectors. The valve number indexes this panel. This panel contains the following information:

From

Time stamp indicating the start of recording (statistics).

Accumulation

Total accumulation in time or volume for the indexed valve.

Sect

The sector number (label) / valve number (index for this panel).

System clock

5.3.4 TOTAL AVERAGES – C 22

```
From: 09-26 13:37;12
05.3pH
06.7mS 13:15
TOTAL AVERAGES C22
```

This panel indicates the overall average of pH and conductivity for the entire irrigation process. This panel contains the following information:

From

Time stamp indicating the start of recording (statistics).

pH

The pH total average.

mS

The EC total average.

System clock

5.3.5 PROGRAM AVERAGES – C 23

```
From: 09-26 13:37;12
05.3pH          Prog 01
06.7mS          13:15
PROGRAM AVERAGES C23
```

This panel provides a pH & EC average for each of the irrigation programs. The program number indexes this panel. This panel contains the following information:

From

Time stamp indicating the start of recording (statistics).

pH

The pH average for the indexed program.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

mS

The EC average for the indexed program.

System clock

5.3.6 SECTOR AVERAGES – C 24

```
From: 09-26 13:37;12
05.3pH          Sect 01/01
06.7mS          13:15
SECTOR AVERAGES C24
```

This panel provides an average pH and EC reading for each of the irrigation sectors. The valve number indexes this panel. This panel contains the following information:

From

Time stamp indicating the start of recording (statistics).

pH

The average pH reading for the indexed valve.

Sect

The sector number (label) / valve number (index for this panel).

mS

The average EC reading for the indexed valve.

System clock

5.4 ALARMS CONSULTING

5.4.1 ACTIVE ALARMS – C 25

```
Low level fert: 4
ACTIVE Alarm
26-12 14:36:22 13:15
ALARM 02/07 C25
```

This displays the active alarms current in the system. Once viewing the panel all of the alarms can be scrolled and viewed using the UP and DOWN or ENTER keys. This panel contains the following information:

Alarm Description

Time of alarm occurrence.

Alarm

The alarm number and (/) total number of all active alarms.

System clock

When at least one active alarm is present, the system clock blinks "ALARM". This indication is displayed on all panels having the system clock.

NOTE: The alarm management system is designed to provide self-update behavior, thereby no user intervention is required to restore the status of the interrupted program once the condition is resolved. If the condition of the active alarms change, the panel will reflect the change accordingly without user intervention.

5.5 LOG CONSULTING

5.5.1 VIEW LOG DATE – C 26

```
Log consulting date:
26-12
15:05
VIEW LOG DATE C26
```

This panel allows the user to view log data from a specific date. The SET key is used to enter the date of choice thus entering the setting mode. After entering the panel and pressing the SET key, the cursor (focus) is shifted from the panel number to the first place of the day indicator. The key pad and arrow keys can be used to enter the selected date followed by the ENTER key. Once ENTER is

pressed the Fertigation Controller will search for the logged data. If no data is found the panel is shifted to C 28 (LOG) and “no records found” is displayed. This panel contains the following information:

Log consulting date

The initial viewing date set by the user.

System clock

5.5.2 ANOMALIES (ALARMS HISTORY) – C 27

```
Low level fert: 4  
CLEARED ALARM  
26-12 14:36:22 13:15  
ANOMALY 0193/22 C27
```

This screen displays anomalies. Anomalies are considered alarm history. This screen displays alarm conditions that are no longer active. Once viewing the panel all of the anomalies (prior alarms) can be scrolled and viewed using the UP and DOWN or ENTER keys.

This panel contains the following information:

Alarm Description

Cleared Alarm indication

Time stamp

Time of alarm occurrence.

System clock

ANOMALY

The anomaly log record number and “/” the number of all anomalies since the system statistics were recorded.

The anomalies log record number can be erased on panel C 61 erasing the statistics.

5.5.3 LOG – C 28

```
Ext state: ACTIVE  
Prog State changed.  
18-08 15:05:30 15:05  
Log 0012 Lev 03 C28
```

The Fertigation Controller log system is a three level hierarchically designed, which means that the events are classified in three selectable categories. The consulting log level displayed in this panel can be changed directly using the

SET key or via panel S 59 (SET LOG LEVELS). The UP and DOWN arrow keys are available to move between log records in a “select previous/next” manner. This panel displays the following information:

Log record

Log record description.

Time stamp

Time stamp of logged occurrence.

Log record number

Log consulting level

System clock

5.6 GENERAL SETTINGS

The Setting panels provide an interface by which the user can set up the functionality of the Fertigation Controller to suite the application requirements. The parameters in any setting panel can be modified only if the user presses the SET key (entering the setting mode). Once pressing the SET key the cursor (focus) is passed to the first adjustable parameter on the panel. Using the keypad along with the arrow keys the user can set the desired parameters and navigate within the panel. The ENTER key validates all entries. In SET MODE panel the browsing methods are disabled until the user exits from SET MODE by pressing the ENTER (validation) or ESC (cancel) key.

To change program number you must go to panel C 03 and then continue.

5.6.1 SET DATE & TIME – S 30

```
Date: Fri-22-09-2000
Time: 17:03:20
                                17:03
SET DATE & TIME S30
```

This panel allows the setting of the following parameters:

Date

Day / Month / Year format. The day is automatically updated once the numeric date is entered and confirmed.

Time

Hour / Minute / Seconds format. The time is automatically updated once the numeric time is entered.

System clock

5.7 PROGRAM SETTINGS

5.7.1 ACTIVE TIMETABLE – S 31

```
Between          Prog 07
Date: 01-04     31-10
Time: 07:00     23:00
ACTIVE TIMETABLE S31
```

This panel allows the user to set the scheduled limits for the indexed program. The program number indexes this panel (For more details see Section 3.1 and Appendix 3). This panel allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Date

The yearly schedule limits for the selected program.

This sets the limit of program operation between day / month and day / month.

Time

The daily schedule limits the selected program. This sets the limit of program operation hour:min to hour:min.

5.7.2 WORKDAYS – S 32

```
Work day 02     Prog 07
Rest day 03
Weekday SMTWTFs
WORKDAY NNNNNNN S32
```

This panel allows the user to set a workday scheduled for the indexed program. Once the yearly and daily limits are established for the indexed program using the previous panel, two methods can be used to set up a consistent work schedule. Workdays and rest days simply stated “days on” and “days off” are selectable.

If the application requires specific days of execution during the week, then specific workdays are selectable by entering a Y (yes) or N (no) under the day of choice. Only one of the methods can be used for each program. By setting one of the two choices the other is deactivated. The program number indexes this panel. This panel displays and allows the setting of the following parameters

(for more details see Section 3.1 and Appendix 3):

Work day

The number of consecutive workdays.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Rest day

The number of consecutive rest days.

Weekday

Week-day labels.

Workday

Use the yes or no indication (on the keypad) below each weekday label to indicate specific workdays for the indexed program.

5.7.3 SET PRIORITY – S 33



This panel allows the setting of priority level for each program. Programs can share the same priority level. When a conflict occurs between two programs with the same priority, the program that has the earliest starting time will be executed first. The program number indexes this panel (For more details see Section 3.1 and appendix 3). This panel displays and allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Priority

The priority level. This number can be set from 1 to 5, where 5 is the highest priority.

Sectors / Group

The number of sectors/groups for the indexed program is the maximum number of valves that will be opened simultaneously.

5.7.4 START CONDITIONS – S 34

```
Time cond y   Prog 07
Solar rad N
Ext tank: -- Link 02
START CONDITION S34
```

Using this panel we can set up how a particular program is triggered (started). Multiple start conditions can be chosen for a program at the same time. In this panel, a program can be set up to activate at a certain time, by the amount of accumulated solar radiation, by the level of an external tank, or directly after the completion of another program. The program number indexes this panel, which displays and allows the setting of the following parameters:

Time cond

Time condition start. On keypad select Y for yes or N for no.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Solar rad

Accumulated solar radiation start. On keypad select Y for yes or N for no.

Ext tank

By selecting external tank trigger, the start of the program is based on the low level of an assigned external tank number.

Link

By selecting Link and entering a master program number, the start of the program directly follows (linked to) the completion of another program.

5.7.5 SET START TIME – S 35

```
                                Prog 07
07:00    09:20    10:30
12:00    14:00    16:00
SET START TIME           S35
```

If time is selected as the starting trigger for an indexed program, we can select up to six different starting times within the daily scheduled limits (see panel S 31, ACTIVE TIMETABLE). When the time start condition is not set on panel S 34 none of the settings on this panel has effect. The program number indexes this panel (for more details see Section 3.1 and Appendix 3). This panel displays and

allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Start times

Six individual (selectable) hour settings start within the daily schedule limits for the indexed program.

NOTE: 00:00 is the not set value of the start time and the irrigation program does not start at 00:00.

5.7.6 SET PROGRAM REPEATS – S 36

	Prog 07
Repeats	04
Pause	00:30:00
PROGRAM REPEATS	S36

Once a program is triggered it is possible to set it to be repeated by using this panel. The program number indexes this panel (for more details see Section 3.1 and Appendix 3). This panel displays and allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Repeats

Selects the total number of repetitions following the initial execution of the indexed program.

Pause

Selects the amount of delay time between repetitions.

5.7.7 PRE/POST IRRIG – S 37

	Prog 07
PreIrrig:	000:00:05
PostIrrig:	000:00:05
PRE/POST IRRIG	S37

Prior to and/or after the execution of the indexed program, the amount of pre and post irrigation can be specified in time or volume. To set irrigation control

mode, see panel S 53 (IRRIG CTRL MODE). The program number indexes this panel (for more details see Section 3.1 and Appendix 3). This panel displays and allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Prelrig

The selectable amount of pre-irrigation in time or volume.

Postlrig

The selectable amount of post-irrigation in time or volume.

5.7.8 SET SECTORS – S 38

Valve	05	Prog	07
Sector	01	Total	03
Value: 00:00:05			
SET SECTORS			S38

Each valve can be set for the indicated program using this panel. The panel allows the setting of the sector (label) number for each valve. A value in time or volume is entered to determine the duration or amount of activation. Once a value is entered, it is considered assigned to the indicated program and added to the total number of valves displayed on the panel. To remove valves from a program simply enter zeros in the value setting. The valve number indexes this panel. This panel displays and allows the setting of the following parameters:

Valve

Panel index.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Sector

Selectable sector (label) number for each valve. Unique or similar numbers can be assigned to the valves.

Total

Total number of valves assigned to the indicated program.

Value

The selectable irrigation (time or volume) value for the indexed valve.

5.7.9 SET FERTILIZERS – S 39

	Prog 07
Fer1=020%	Fer2=055%
Fer3=060%	Fer4=040%
SET FERTILIZERS	S39

The fertilizer dosing is controlled by conductivity. The Fertigation Controller can control up to 4 fertilizer tanks. Using this panel we can set a percentage of each dosed fertilizer. Each tank can be set to dose from 0 to 100%.

Setting each tank to dose 100% would represent maximum dosing of all fertilizers relative to the conductivity set point and control settings. The program number indexes this panel. This panel displays and allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Fert settings

Selectable fertilizer settings (percent) for tanks 1 through 4.

5.7.10 pH CONTROL – S 40

pHRef=07.3pH	Prog 07
-00.5pH	+00.5pH
Alarm threshold: 02	
pH CONTROL	S40

Typically an acid is added to reduce the pH to a desired level. The Fertigation Controller can control one acid tank. A desired pH set point or target reference is programmed and the acid dosing is controlled relative to the set point. The program number indexes this panel. This panel displays and allows the setting of the following parameters:

pH Ref

The selectable pH set point programmed for acid dosing.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Dead band

The selectable dead band around the pH reference. The desired (target) pH range.

Alarm threshold

Selectable pH control alarm threshold represents the time interval (measured in the Fertigation Controller's control cycles) considered from the moment when the alarm condition actually appears and the moment when the alarm will be triggered.

5.7.11 COND CONTROL – S 41

```
ECRef=07.3mS Prog 07
-00.5mS +00.5mS
Alarm threshold: 02
COND CONTROL S41
```

The EC settings are programmed using this panel. EC control determines the overall amount of fertilizer added to the irrigation water in order to maintain the desired conductivity value. Using this panel the Fertigation Controller controls up to 4 acid tanks relative to the established EC settings. The program number indexes this panel. This panel displays and allows the setting of the following parameters:

EC Ref

The selectable EC set point programmed for fertilizer dosing.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Dead band

The selectable dead band around the EC reference. The desired (target) EC range.

Alarm threshold

Selectable pH control alarm threshold represents the time interval (measured in the Fertigation Controller's control cycles) considered from the moment when the alarm condition actually appears and the moment when the alarm will be triggered.

5.7.12 CORRECTIONS – S 42

```
Manual +050% Prog 07
SolRad irrig +010%
CORRECTIONS S42
```

This panel allows the setting of corrections (adjustments) to the irrigation and

fertilization process. The program number indexes this panel. This panel displays and allows the setting of the following parameters:

Manual

The selectable manual adjustment to the irrigation process.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

SolRad irrig

The selectable adjustment to the irrigation process as a result of the effects of accumulated solar radiation.

5.7.13 SOLAR RAD IRRIG – S 43

<p style="text-align: center;">Prog 07 Level: 0350W/m2 Accumul: 2500Wh/m2 SOLAR RAD IRRIG S43</p>

This panel allows the settings regarding the accumulated solar radiation feature. The program number indexes this panel. This panel displays and allows the setting of the following parameters:

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Level

The selectable solar radiation sensor threshold.

Accumul

The selectable solar radiation accumulation threshold used to initiate the counting of accumulation for irrigation control.

5.7.14 SET AGITATORS – S 45

<p>Pre 00:33 Prog 08 Work 00:10 Pause 00:05 SET AGITATORS S45</p>

An agitator can be assigned to each of the 4 fertilizer tanks . The agitators can be activated before dosing the fertilizer, during dosing, or intermittently throughout the program. If “Pre” is set, the agitator will activate prior to dosing. If “Work” is set without “Pause” the agitator will work throughout the lifetime of the

program. If “Work” and “Pause” are set the agitator will function intermittently relative to the time settings. In this panel the agitator number is used as the index. This panel displays and allows the setting of the following parameters:

Pre

The selectable pre-activation time for the agitator. The pre-agitation is done only if the program has pre-irrigation and during of it.

Program Number

Reflects the selected program (can be selected only inside panel C 03). See Section 5.2.

Work

The selectable activation time for the indexed agitator. Working time during irrigation.

Pause

The selectable pause time following work time setting.

5.7.15 FILTERS CTRL – S 46

```
Link 05      Filter 01
Clean on alarm: Y
Clean time: 01:01:02
FILTERS CTRL      S46
```

Both filter-cleaning programs are set via this panel. In this panel the Filter number is used as the index. This panel displays and allows the setting of the following parameters:

Link

The selectable program (number) after which the filter-cleaning program is activated.

Filter Number

Panel index. Two filter selectable.

Clean on alarm

The filter-cleaning program can be set to be activated by an alarm condition alone or in addition to being linked to a specific program. Enter Y (yes) or N (no).

Clean time

Selectable work duration for the indexed filter cleaning program.

5.8 MANUAL COMMANDS

5.8.1 MANUAL START – S 47

```
Active program: 03
Start program:  -- ?

PROG MAN START      S47
```

Each program can be manually started using this panel. If certain alarm conditions are present such as “no water supply”, a program cannot be started by any means. When a program is started normally during this activation it has the highest priority in the system, after that the program returns to the normal, set priority. This panel displays and allows the setting of the following parameters:

Active program

The currently active program.

Start program

The program selected for activation. User selectable.

5.8.2 MANUAL STOP – S 48

```
Active program: 03
Stop program:  -- ?

PROG MAN STOP      S48
```

Each program can be manually stopped using this panel. This panel displays and allows the setting of the following parameters:

Active program

The currently active program.

Stop program

The program selected for deactivation - user selectable.

5.8.3 CONTROLLER STATE – S 49

```
STOP - WORK
WORK -
INIT -
CONTROLLER STATE S49
```

This panel allows manual manipulation of the controller state. Once entering the set mode, one of the three conditions can be selected using the arrow keys.

Y (yes) can be entered next to the selected condition to change the controller state. Only the Y (yes) key will have effect in activating the appropriate state. This panel displays and allows the setting of the following parameters:

Stop

Press Y (yes) then *ENTER* to place the controller in stop state.

Current controller status

Work

Press Y (yes) then *ENTER* to place the controller in work state. If there are certain alarm conditions it is not possible to enter *WORK* state.

Init

Press Y (yes) then *ENTER* to place the controller in initialization state.

5.8.4 OUTLET MAN CTRL – S 50

```
Number: 27
Opened: Y
Value: -
OUTLET MAN CTRL S50
```

In this panel the outlet number is used as the index. See Appendix 2 with outlet assignment. This panel displays and allows the setting of the following parameters:

Number

Panel index. Outlet number.

Opened

The status of the indexed outlet.

Value

Press Y (yes) or N (no) to open or close the indexed outlet.

5.9 CUSTOMIZED SETTINGS

5.9.1 PH CTRL OPTIONS - S 51

```
Ctrl in Pre/Post Y
Use acid in pHCtrl Y
pH CTRL OPTIONS S51
```

This panel allows selection of pH control options. The control in “pre” and “post” irrigation states as well as acid/base selection are selectable. This panel displays and allows the setting of the following parameters:

Ctrl in Pre / Post

Press Y (yes) then *ENTER* to control pH prior and after irrigation.

Use acid in pH Ctrl

Press Y (yes) or N (no) then *ENTER* to control dosing of acid or base.

5.9.2 ALARM BEHAVIOR – S 52

```
Ctrl on pH alarm: Y
Irrig on pH alarm: Y
Ctrl on EC alarm: Y
ALARM BEHAVIOR      S52
```

This panel allows the selection of specific alarm behavior. Once entering the set mode, one of the three choices can be selected using the arrow keys. Y (yes) can be entered next to the selected option. Y (yes) and N (no) keys are used to select the option of continuing or stopping control or irrigation during a pH or EC alarm condition. This panel displays and allows the setting of the following parameters:

Ctrl on pH alarm

Pressing Y (yes) then *ENTER* allows the controller to continue the pH control execution during a pH alarm condition.

Irrig on pH alarm

Pressing Y (yes) then *ENTER* allows the controller to continue irrigation during a pH alarm condition.

Ctrl on EC alarm

Pressing Y (yes) then *ENTER* allows the controller to continue the conductivity control execution during an EC alarm condition.

5.9.3 IRRIG CTRL MODE – S 53

```
Volume control: N
Time control: Y
IRRIG CTRL MODE S53
```

This panel allows the selection of control based on time or volume. This feature, once set applies to all programs of the Fertigation Controller. Y (yes) and N (no) keys are used to select only one of the two options. Switching the control mode is only possible if no active programs are running.

5.9.4 CALIBRATE SENSORS – S 54

```
Channel: 01
Now: 02.3 Ref: 02.5
Status: First Stage
CALIBRATE SENSOR S54
```

The sensor calibration procedure consists of two stages. Each stage is initiated by pressing *SET* key. Both stages are required to complete the calibration procedure. For more information see Section 7.1 SENSOR CALIBRATION PROCEDURE. The channel number indexes this panel. This panel displays and allows the setting of the following parameters:

Channel number

Panel index. The Fertigation Controller is equipped with 8 channels for various sensor inputs. The channels are configured as follows:

1. pH 1 Sensor (4-20 mA analog input)
2. pH 2 Sensor (4-20 mA analog input)
3. EC 1 Probe (4-20 mA analog input)
4. EC 2 Probe (4-20 mA analog input)
5. EC IN Probe (4-20 mA analog input), 3rd optional EC probe for monitoring incoming water supply.
8. Solar Radiation sensor (2 volt analog signal)

Now

Real time sensor value for the indexed channel.

Ref

The calibration reference value (entered by the user) for the indicated stage of calibration, for the indexed channel.

Status indication

Current state of the calibration procedure (current stage/result).

5.9.5 SENSORS CONFIG – S 55

```
PH Cfg          EC Cfg:
SensNr=02       SensNr=03
SDif=03.2       SDif=03.3
SENSORS CONFIG  S55
```

This panel allows the setting of acceptable difference between the probes in the system. An alarm condition is triggered when the allowable distance is exceeded. This panel displays and allows the setting of the following parameters:

SensNr = The selectable number of pH sensors in the system (1 to 2).

SensNr = The selectable number of EC sensors in the system (1 to 3).

SDif

The maximum allowable distance between the pH sensors values.

SDif

The maximum allowable distance between the EC sensors values and also the maximum value that is acceptable on the water supply sensor.

5.9.6 SET FLOW PARAMETERS – S 56

```
Flow=010L      Sect 01
L/impulse=060
SET FLOW PARAMS  S56
```

If flow is chosen as the irrigation control variable, this panel allows the setting of the flow parameters. The sector number indexes this panel. This panel displays and allows the setting of the following parameters:

Flow = The selectable volume for the indexed sector.

Sect

The panel index. The sector number (label).

L / impulse = Selectable flow value per one impulse of the flow counter.

5.9.7 SET PID PARAMETERS – S 57

```
PHk=01.0  ECK =01.3
PHTi=10.0  ECTi =10.0
PHTd=00.5  ECTd =00.5
SET PID PARAMS  S57
```

This panel allows the setting of the control action for pH and EC. This panel displays and allows the setting of the following parameters:

pHk

Factory amplification setting for pH control (controller gain).

pHTi

Integral constant for pH control. Reset time. Setting the value to 99.9 minutes effectively disables the integral function.

pHTd

Derivative constant for pH control. Rate time. Setting the value to 0.00 minutes effectively disables the derivative function.

Eck

Factory amplification setting for EC control.

ECTi

Integral constant for EC control. Setting the value to 99.9 minutes effectively disables the integral function.

ECTd

Derivative constant for EC control. Rate time. Setting the value to 0.00 minutes effectively disables the derivative function.

NOTE: For automatic PID correction insert 00.0 in pHk and in Eck.

5.9.8 SET TIMINGS – S 58

```
Start delay: 03s
Stop delay: 03s
Time cycle: 02.0s
SET TIMINGS          S58
```

This panel displays and allows the setting of the following parameters:

Start delay

Selectable start delay value for the main pump as it relates to the open command for the first active sector.

Stop delay

Selectable stop delay value for the main pump as it relates to the close command for the last active sector.

Time cycle

The complete cycle duration factor for the controller.

WARNING!

It is strongly suggested that only specialized personnel modify these settings.

5.9.9 SET LOG LEVELS – S 59

```
Recording level: 03
Consulting level: 03

SET LOG LEVELS      S59
```

The Fertigation Controller's logging system is a three level hierarchical system. A set of categories are assigned to each of the 3 levels; these events are re-

corded and can be inspected at the same time. Alarm events are stored regardless of log level and can be inspected using panel C 27 (ANOMALY). Panel S 59 displays and allows the setting of the following parameters:

Recording level:

The selectable log recording levels range from 1 to 3.

Level 1: records the sensors deviations events

Level 2: records statistics (pH and EC averages, accumulations)

Level 3: records programs and controller status events

Consulting level:

Selectable log consulting level (from 1 to 3). This parameter allows the user to select the log event categories (see above) that will be inspected on panel C 28. This parameter can be also modified during log consulting sequence within panel C 28.

5.9.10 SET PASSWORD – S 60

```
Disable password: N
New password: ---

SET PASSWORD      S60
```

This panel allows the setting of a system password. Any changes that are made to the settings of this panel require password authorization. This panel displays and allows the setting of the following parameters:

Disable password:

Choosing Y for the “Disable password” option will allow free access to the Fertigation Controller after every start-up sequence, while choosing N will enable start-up after which password authorization will be required to view display panels.

New password: New password input. Numeric format only.

NOTE: The function of the Fertigation Controller is not effected due to a failed or successful password authorization process during log on.

5.9.11 ERASE STATISTICS – S 61

```
      Erase all: -  
      On overflow: Y  
      Daily at hour: 00:01  
      ERASE STATISTICS S61
```

With this panel it is possible to erase stored statistics pertaining to controller function manually, on overflow, or at a certain time. Enter Y (yes) or N (no) next to the selection or time for daily option.

Erase all

Manual command to erase statistics.

On overflow

Selecting this option sets the controller to erase statistics upon data overflow.

Daily at hour

Statistics can be erased daily by entering a specific time.

5.9.12 ERASE SETTINGS – S 62

```
      Erase program: --  
      Erase all programs -  
      ERASE SETTINGS      S62
```

With this panel it is possible to erase the settings of a specific program or all programs. Erasing settings from an irrigation program provides a very useful and easy mechanism to set one or all program parameters to null (default) values. This operation will place a program in a *NOT SET* state meaning that it is disabled. This function is only possible if a program is not active. Once the command is accepted a delay period of approximately 3 seconds occurs. This panel displays and allows the setting of the following parameters:

Erase program

Program number input.

Erase all programs

Selecting this option, Y (yes) or N (no), erases the settings for all nonactive programs.

This operation will automatically reset the Fertigation Controller.

6 CALIBRATION PROCEDURES

6.1 SENSOR CALIBRATION PROCEDURE

The purpose of calibrating the Sensor's used in conjunction with the Fertigation Controller is to compensate and adjust the output of the sensors to align with the software of the controller. As time passes the sensors change output slightly due to wear and age making calibration necessary for optimum performance. Monitoring probe performance with known standards and buffers easily identifies the need for calibration. The calibration procedure is performed using panel S 54 (CALIBRATE SENSOR) and to each analog sensor a channel number is assigned that is the index for panel. For each sensor chosen for calibration two measurements with two different known standards are used. For pH you can use 7.7 pH buffer and 4.0 / 10.0 pH buffer, depending on the type of measurement (acid or alkaline). For EC you can use 0 mS (sensor removed from the solution) and 5 mS buffer. For each of the 2 stages of calibration, the calibration panel displays the actual reading and a reference input. The buffer value is entered in the reference input. Prior to calibration rinse the pH and EC sensors with pure water to insure a clean probe and avoid cross contamination. Place the sensor in the first standard or buffer and wait for stabilization. For pH calibration stir gently the buffer with the pH sensor. For EC calibration tap gently the sensor and stir the buffer to insure that no air bubbles are trapped inside the sensor sleeve. Once the reading is stable press *ENTER* to advance to stage 2. Rinse again and place the electrode in the second standard, wait for stabilization and then press *ENTER*. The calibration is complete and the panel will display "done".

For best results the calibration buffers (standards) should be considerably different (e.g. pH 7.01 and pH 4.01 buffer) but not excessively close to the limits of the sensor range. After the calibration is complete (both calibration stages complete) rinse and reinsert the probe into the 2 standards to insure the accuracy of calibration. If the probe does not read correctly this may indicate that the same solution (or nearly the same) was used in both stages of calibration or improper values were supplied as a reference or the probe is malfunctioning.

Regarding solar radiation calibration, the last digit of the entered reference value is considered 0 due to the 10 W/m² resolution of the reading.

6.2 PID TUNING PROCEDURE

For the PID controller, we have three working modes:

1. With PID regulation algorithm (Proportional, Integrative and Derivative);
2. With Proportional regulation algorithm;
3. AUTO TUNING mode.

We will have one of the previous working modes as follows:

K	T_i	T_d	REGULATION TYPE
> 0	< 99.9	> 0	PID
> 0	99.9	0	PROPORTIONAL
0	ANY VALUE	ANY VALUE	AUTO TUNING (DEFAULT)

1. Having all the three components (Proportional, Integrative and Derivative), the PID regulation algorithm has the best precision. This has the disadvantage of requiring a most difficult tuning procedure especially for untrained personnel.
2. The Proportional regulation algorithm is very simple in implementation and also in tuning procedure, but the working mode is not so good. It is used mainly in systems where the dead time (the time from the on command to the response of the system) is very small. This has the disadvantage that for non errors (the measurement value in system reaches the reference value), the output command is null.

Thus, in order to have an output command it is firstly necessary for the system to produce an error (measurement value is different from the reference value), which will have the effect of producing an output command in sense of minimizing that error.

3. Auto Tuning algorithm is an algorithm that makes his own adjustment for the output value. It has the advantage that the user is not involved in the tuning process. From the accuracy point of view, this algorithm is situated between the PID (well tuned) and Proportional regulators.

In the following sections we present the tuning methods for the first two types of controllers (PID and Proportional), the third (AUTO TUNING) not involving the user in the tuning process.

6.2.1 PID TUNING PROCEDURE

Due to the fact that the pH and EC controls function with minimal error at the control output value, the PID controller must be tuned separately for each process (pH and EC).

To access the PID parameters use panel S 57 (SET PID PARAMETERS). The displayed PID parameters are as follows:

pH

Factory amplification setting for pH control (controller gain).

pHTi

Integral constant for pH control.

pHTd

Derivative constant for pH control.

ECk

Factory amplification setting for EC control (controller gain).

ECTi

Integral constant for EC control.

ECTd

Derivative constant for EC control.

1. CONDITIONS THAT IMPOSE THE TUNING OF THE PID CONTROLLER

- Each time when a new installation is turned on.
- Each time when mechanical modifications are made within the irrigation installation (pump, pipes, electro valves, etc.).
- If the water source from which the irrigation is made is changed.
- If the substance for neutralization is changed (or its concentration).
- When the controller is replaced.

2. NECESSARY STEPS FOR TUNING THE PID CONTROLLER

Tuning the PID controller necessitates successive tests with different values of the approval parameters. The following method needs increase of the K amplification factor up to the steady level of the system's oscillation. Below is presented a user-friendly procedure for this tuning.

During the PID tuning (for pH as well as for EC) we are going to have big variations of the outlet value (the pH and EC of the irrigation water) compared to the prescribed value. This is the reason why during the tuning the water that exits the pump has to be directed to a collecting channel designed for residual water and not to irrigation (for the protection of the crops).

In the above case we are going to set only one sector.

A. NECESSARY STEPS FOR TUNING THE PID CONTROLLER FOR PH ADJUSTMENT

1. The pH of the water source used for irrigation is measured. When this value is smaller than the reference value (is acid), the substance from the tank used for neutralization is going to be alkaline. In opposite case the neutralization substance is going to be acid.
2. Based on this measurement set the S 51 panel of the controller (Use acid in pHCtrl) with "N" (for an alkaline neutralization substance), and "Y" (for an acid neutralization substance).
3. Proceed to panel S 37 (PRE/POST IRRIG) and with the UP, DOWN arrows select the irrigation program number 10. This program has as default settings (given by the manufacturer):
 - The total number of sectors = 1
 - Irrigation time = 15 minute
4. Proceed to panel S 38 (SET SECTORS) to verify these settings. If they are different than those from above they have to be set.
5. Set the reference value for pH and the range for its allowable variation (any sensor's input value that exceeds this range will trigger an alarm) in panel S40 (PH CONTROL).
6. Make sure that all the other programs are stopped. For each program (from 1 to 9) we are going to set in panel S 32 (WORKDAY) as "N" (inactive) .
7. Verify if for program 10 in panel S 08 (WORKDAY) the working time is valid for the day when we are making the tuning (the current day). If not proceed to set it in panel S 32 (WORKDAY).
8. In panel S 59 (SET LOG LEVELS) set the following options: *Recording level* = 01; *Consulting level* = 01. This means that the log is going to be consulted for sensors' value and the log registrations are going to be read by the sensors (pH, respective EC).

With the above settings we are going to have the irrigation time set for a single sector in panel S 38 (SET SECTORS). The starting condition is manual starting - in panel S 47 (PROG MAN START).

Next we set the PID parameters for pH in panel S 57 (SET PID PARAMS), as follows:

$$\begin{aligned} \text{pHk} &= 1.0 \\ \text{pHTi} &= 99.9 \\ \text{pHTd} &= 0.0 \end{aligned}$$

With the above setting we are going to have a Proportional regulation for pH.

9. From panel S 47 (PROG MAN START) we start manually program 10. Wait until the set time expires (15 minutes for default setting).

10. At the end of the program consult the log table. Write down in a table the values for the pH sensor and the time when the reading was done (see Section 4.10, LOGGING (DIARY) FUNCTIONS).
11. The obtained data is used to compose a graphic having as horizontal axis the time and vertical axis the pH variations. The next step is to analyze the obtained graphic.
12. Increment the amplification constant's value gain (pHk) from panel S 57 (SET PID PARAMS). Repeat steps 9, 10, 11 and 12 until the form of the wave corresponding to pH variation has the sinusoid shape with approximately constant amplitude (unamortized oscillation).

NOTE: The period of time for Irrigation time (15 minute default) - panel S 37 (PRE/POST IRRIG) - can be modified (increased or decreased), if the process is very slow or very fast.

Write down the final value obtained with pHk_0 (for the amplification factory).

For this pHk_0 obtained value, measure the period of oscillation (expressed in seconds). In accordance with the following relations determine the 3 factors:

$$pHk = 0,75 * pHk_0$$

$$pHTi = 0,6 * T_0$$

$$pHTd = 0,1 * T_0$$

Using the above settings we are going to have a Proportional, Integrative and Derivative control for pH.

If you want to obtain an other type of control please proceed to the next settings.

For P controller:

$$pHk = 0,5 * pHk_0$$

$$pHTi = 99.9$$

$$pHTd = 0$$

For PI controller:

$$pHk = 0,4 * pHk_0$$

$$pHTi = 0,8 * T_0$$

$$pHTd = 0$$

These values are going to be set in panel S57 (SET PID PARAMS). With these values the pH tuning of the PID controller is considered finished.

B. NECESSARY STEPS FOR TUNING THE PID CONTROLLER FOR EC ADJUSTMENT

1. Go to panel S 37 (PRE/POST IRRIG) and using the UP, DOWN arrows select the irrigation program number 10. This program has the following default settings :

- Total number of sectors = 1
 - Irrigation time = 15 minute
2. Go to panel S 38 (SET SECTORS) and check the above settings. If they are different adjust them.
 3. Set the reference value for EC and the range for its allowable variation (any sensor's input value that exceeds this range will trigger an controller the alarm) in panel S 41 (COND CONTROL).
 4. Make sure that all the other programs are stopped. For each program (from 1 to 9) we are going to set in panel S 32 (WORKDAY) for the current day an "N" (inactive).
 5. Check in panel S 08 (WORKDAY) if the working period for program 10 is valid for the day in which we made the tuning (the current day). If not proceed to set it in panel S 32 (WORKDAY).
 6. Set in panel S 59 (SET LOG LEVELS) the following options: *Recording level = 01*; *Consulting level = 01*. This means that consulting the log is going to be made for the sensors' value and the registrations in log are going to be those read by the sensors (for pH, respective EC).

With the above settings we are going to have an irrigation time set in panel S 38 for a single sector. The starting conditions are going to be those for manual starting - from panel S 47 (PROG MAN START).

Next we are going to set the PID parameters for EC in panel S 57 (SET PID PARAMS), as follows:

$$Eck = 1.0$$

$$ECTi = 99.9$$

$$ECTd = 0.0$$

With the above settings we are going to have a Proportional setting for EC.

7. Start manually program 10 from panel S 47 (PROG MAN START) and wait until the setting time expires (15 minutes default).
8. After the program ends consult the log table. From this you are going to write down in a table the sensor's EC readings and the time when the reading has been done (see Section 4.10, LOGGING (DIARY) FUNCTIONS).
9. With the obtained data, make a drawing having as horizontal axis the time and vertical axis the EC variations. Analyze the obtained chart.
10. Increment the gained amplification constant's value (Eck) in panel S 57 (SET PID PARAMS). Repeat the steps 7, 8, 9 and 10 until the wave corresponding to the EC variation is sinusoid type that has approximately constant amplitude (unamortized oscillation).

NOTE: The period of time for Irrigation time (15 minute default) - panel S 37 (PRE/POST IRRIG) - can be modified (increased or decreased), if the process is very slowly or very speed.

Write down the final value obtained with Eck_0 (for the amplification factor).

For this Eck_0 value, measure the oscillation period (expressed in seconds).

Based on the following relations, determine the 3 factors of PID tuning:

$$Eck = 0,75 * Eck_0$$

$$ECTi = 0,6 * T_0$$

$$ECTd = 0,1 * T_0$$

Using the above settings we are going to have a Proportional, Integrative and Derivative control for EC.

If you want to obtain other type of control please proceed at next settings.

For P controller: $Eck = 0,5 * Eck_0$

$$ECTi = 99.9$$

$$ECTd = 0$$

For PI controller: $Eck = 0,4 * Eck_0$

$$ECTi = 0,8 * T_0$$

$$ECTd = 0$$

These values are going to be set later in panel S 57 (SET PID PARAMS). With these values for the tuning parameters, the PID controller for EC is considered tuned.

6.2.2 PARTICULAR CASES FOR PID TUNING PROCEDURE

1. AMPLIFICATION CONSTANT (pHK OR ECK) TOO LARGE

- The output of the controller oscillates between repletion and blockage depending on the error of the process.
- The valves will be opened all the time or blocked (closed) depending on the variation of the process.

2. AMPLIFICATION CONSTANT (pHK OR ECK) TOO SMALL

- The output of the controller varies insignificantly and doesn't compensate adequately for the variations in the system.
- The opening and the closing periods vary slightly from one control cycle to another creating a chaotically evolving process (cannot achieve stability).

3. INTEGRATIVE CONSTANT (pHTI OR ECTI) TOO LARGE

- Integral effect is limited.

- The control function remains constant; however, a steady state offset is present meaning that the set point is never completely maintained.

4. INTEGRATIVE CONSTANT (pHTI OR ECTI) TOO SMALL

- Integral effect is excessive.
- The control variable (process) enters a state of oscillation.
- A saturation effect occurs creating a “blocking effect” of the controller outputs depending on the magnitude of the error in the process.
- The valve function will be unstable, opening and closing frequently.

5. DERIVATIVE CONSTANT (pHTD OR ECTD) TOO LARGE

- Creates unnecessary upsets in the process (spikes).

6. DERIVATIVE CONSTANT (pHTD OR ECTD) TOO SMALL

- The control variable (process) enters a state of oscillation.
- The valves remain in an opened or blocked (closed) state.

7 ALARM DESCRIPTION

There are 8 kinds of possible software alarms that may occur during the operation of the Fertigation Controller.

1. “pH SENSOR DIFF”

This alarm is triggered if the difference between the real time values of the two primary pH sensors exceed the specified maximum allowable difference. The maximum allowable difference (offset) between pH sensor values can be customized using panel S 55 (SENSORS CONFIG). This particular alarm condition has a customizable threshold limit, which can be set by using panel S 40 (pH CONTROL). The threshold limit is an adjustable time response to a given alarm condition.

2. “EC SENSOR DIFF”

This alarm is triggered if the difference between the real time values of the two primary EC sensors exceed the specified maximum allowable difference. The maximum allowable difference (offset) between EC sensor values can be customized using panel S 55 (SENSORS CONFIG). This particular alarm condition has a customizable threshold limit, which can be set by using panel S 41 (COND CONTROL). The threshold limit is an adjustable time response to a given alarm condition.

3. “pH OUT OF RANGE”

This alarm is triggered when the real time value of the primary pH sensor (pH

sensor #1) is outside of the allowable dead band determined by the specified pH Reference value together with the pH min and pH max offset limits. These parameters can be set using panel S 40 (pH CONTROL).

4. “EC OUT OF RANGE”

This alarm is triggered when the real time value of the primary EC sensor (EC sensor #1) is outside of the allowable dead band determined by the specified EC Reference value together with the EC min and EC max offset limits. These parameters can be set using panel S 41 (EC CONTROL).

5. “DIRTY FILTER: n”

This alarm indicates that the “n” designated filter requires cleaning. The customizable alarm behavior of the Fertigation Controller allows automatic execution of the corresponding filter cleaning program or only the alarm with continuation of normal function with no execution of a filter-cleaning program. These parameters can be set using panel S 46 (FILTERS CTRL), “Clean on alarm” option.

NOTE: This option, when set for filter #1 or filter #2, applies to BOTH filter-cleaning programs.

6. “LOW LEVEL FERT: n”

This alarm is triggered if the fertilizer level of the “n” designated tank has reached a minimum value. Once this alarm is triggered, the assigned valve will close and that fertilizer tank will be excluded from use during EC control of the irrigation process.

7. “LOW LEVEL ACID”

This alarm is triggered if the level of the acid (or alkaline) tank has reached a minimum value. Once this alarm is triggered, the assigned valve will close and that tank will be excluded from use during the pH control of the irrigation process.

8. “NO WATER SUPPLY”

This alarm is triggered due to an incoming water supply failure event.

The Fertigation Controller is automatically switched to BLOCK state and all irrigation programs are SUSPENDED until this event clears. *Once the event is cleared the Fertigation Controller automatically resumes normal operation in the previous state without any external intervention.*

8 TROUBLE SHOOTING GUIDE

THE CONTROLLER DOES NOT FUNCTION

Check to insure that the proper voltage is applied to the controller. After connecting the controller to the power supply (wall outlet), the unit should initiate and the Hanna logo should appear on the LCD. If this does not occur you should check the main fuse located next to the power input connections. If changing the fuse does not solve the problem, call a Hanna Instruments Technical Support.

The alarm led is on

This could indicate that the controller is attempting to open a valve (activate a relay) on the PCB. This most likely is caused by a blown fuse on the PCB relay .

The alarm led is blinking

If the alarm led is blinking this indicates that a software alarm has occurred. Check panel C25 (ALARM) to determine what type of alarm condition is active.

Mixing tank empty

Check water level in mixing tank. The controller will not function without a proper water level in the mixing tank. Check the integrity of the tank and the water supply lines.

pH sensor difference

This alarm is triggered if the difference between the real time values of the two primary pH sensors exceed the specified maximum allowable difference. The maximum allowable difference (offset) between pH sensor values can be customized using panel S55 (SENSORS CONFIG). If the alarm condition persists even after corrective measures, check the calibration of each probe to insure proper function.

EC sensor difference

This alarm is triggered if the difference between the real time values of the two primary EC sensors exceed the specified maximum allowable difference. The maximum allowable difference (offset) between EC sensor values can be customized using panel S55 (SENSORS CONFIG). If the alarm condition persists even after corrective measures, check the calibration of each probe to insure proper function.

pH sensor out of range

This indicates that the controller cannot adjust the pH value of the process within the specified range. Check panel S40 (PH CONTROL) to insure the settings are correct. Also you should check the pH tank and supply lines for proper level and function. Check the pH level of the incoming water to determine if a change has

occurred that may not be correctable by the type and amount of acid (or base) being used. If the problem persists after checking the process pH and acid or base supply, check panel S57 (SET PID PARAMETERS) to insure that the control algorithms are correct.

EC sensor out of range

This indicates that the controller cannot adjust the EC value of the process within the specified range. Check panel S41 (COND CONTROL) and S39 (SET FERTILIZERS) to insure the settings are correct. Also you should check the 4 EC tanks and supply lines for proper level and function. Check the EC level of the incoming water to determine if a change has occurred that may not be correctable by the type and amount of fertilizers being used. If the problem persists after checking the process EC and fertilizer supplies, check panel S57 (SET PID PARAMETERS) to insure that the control algorithms are correct.

Program not set correctly

The minimum conditions that have to be set in order to have the program working are:

- At least one sector has to be set (the irrigation value is different from zero)
- Priority set between 1 and 5
- Sector / group set between 1 and 8
- At least one Start condition has to be selected
- All the time constrains have to be met (see panels S 31 and S 32)

Incorrectly displayed sensor values

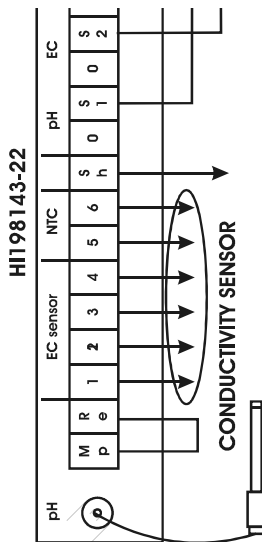
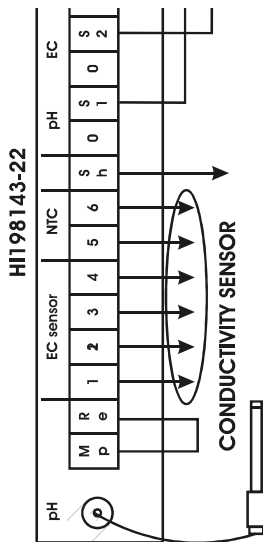
Recalibrate sensors.

Output valve does not work

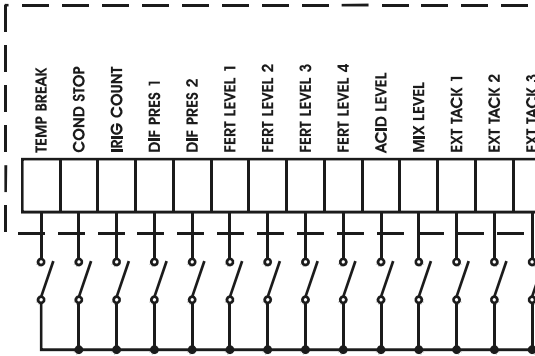
Check sector fuses. If the alarm output does not work when the correspondent led is on, check the fuse to the right of the alarm connector. If the rapid valves that control the pH, conductivity and filters do not function when the correspondent led is on, check the fuse to the right of the fast valve connector. If the basic valves outputs (valve 1 through 8) do not work when the correspondent led is on check the fuse to the right of the basic valve connector.

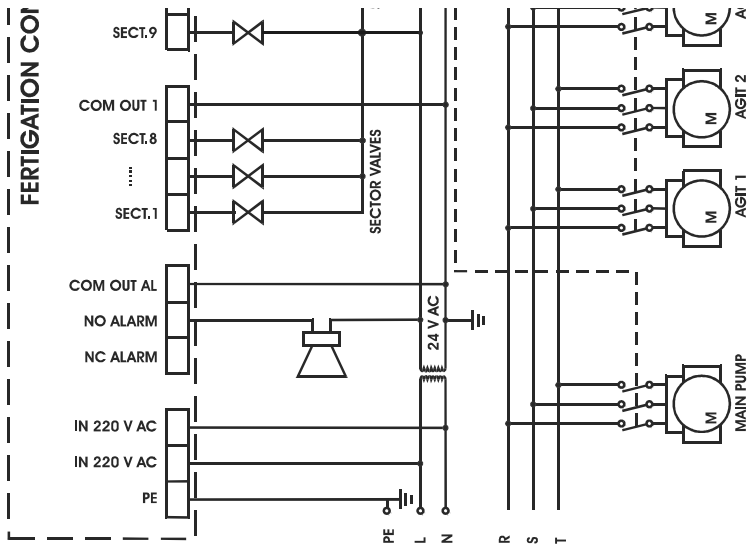
9 ELECTRICAL DIAGRAMS

★ Connected to the 3rd transmitter
HI198143-22 (S2 output)



DIGITAL INPUT CONNECTIONS

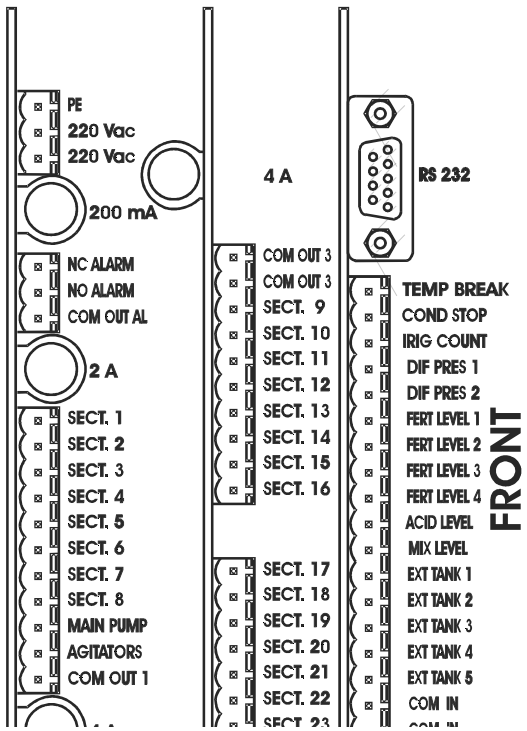




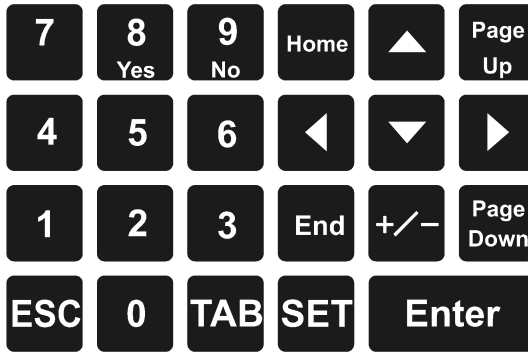
POWER BOARD

EXTENSION BOARD

MAIN BOARD



APPENDIX 1- KEYBOARD OPERATING MODES



CONSULTING MODE:

- **arrow** keys can be used to navigate inside the currently focused object
- **ESC** key can be used as a shortcut to the PROGRAM STATE panel
- **Home** key acts as a shortcut to the GENERAL INFO panel
- **End** key acts as a shortcut to the MANUAL STOP panel
- **TAB** key can be used to move between the panel number and the panel index parameter if one exists on the current panel.
- **Enter** key is used to validate new values entered in the currently focused parameter.

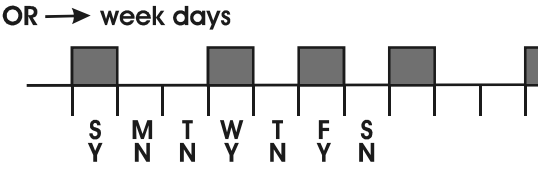
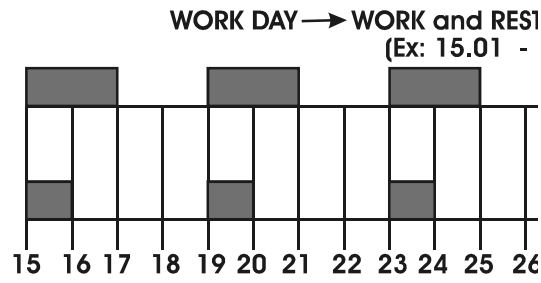
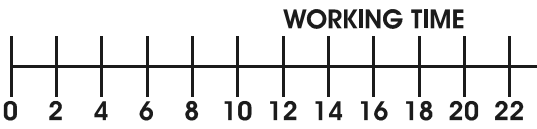
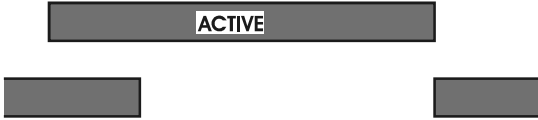
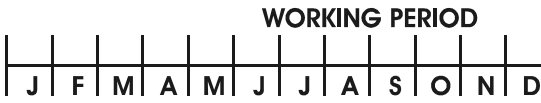
SETTING MODE:

- **Up, Down arrow** keys can be used for navigating between all editable parameters
- **Left, Right arrow** keys can be used to navigate inside the currently focused parameter
- **TAB** key can be used to move only in forward direction between editable parameters
- **Enter** key can be used to validate all data exchanges in the current panel and enables switching back to CONSULTING MODE.
- **ESC** key can be used to cancel the last data exchange for the last focused object and enables switching back to CONSULTING MODE.

APPENDIX 2 - OUTLET ASSIGNMENT TABLE

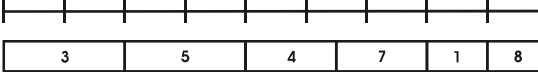
OUTLET NUMBER		ASSIGNED ELEMENT	
08	Filter1	35	SECTOR VALVE 12
09	Filter2	36	SECTOR VALVE 13
10	pH	37	SECTOR VALVE 14
11	Fert1	38	Sector Valve 15
12	Fert2	39	Sector Valve 16
13	Fert3	40	Sector Valve 17
14	Fert4	41	SECTOR VALVE 18
15	Alarm	42	SECTOR VALVE 19
16	Pump	43	SECTOR VALVE 20
17	Agitators	44	SECTOR VALVE 21
24	Sector Valve 1	45	SECTOR VALVE 22
25	Sector Valve 2	46	SECTOR VALVE 23
26	Sector Valve 3	47	SECTOR VALVE 24
27	Sector Valve 4	48	SECTOR VALVE 25

APPENDIX 3 - GRAPHICAL EXPLANATION

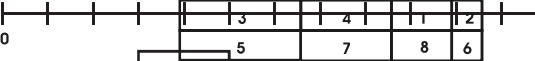


PRIORITY

1 SECTOR/GROUP



2 SECTORS/GROUPS



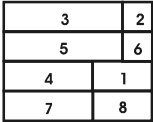
3 SECTORS/GROUPS



P 3



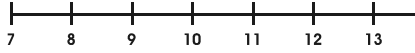
4 SECTORS/GROUPS



WITHOUT REPEAT

START TIME

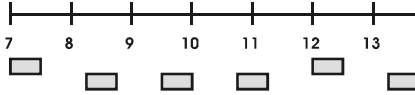
START AT 7:00 END 12:00



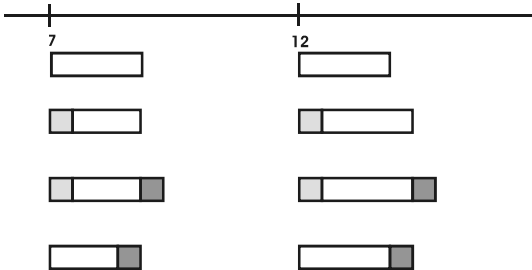
REPEAT 4
Time 00:45:00

WITH REPEAT

START
REPEATS



PRE / POST IRRIGATION



APPENDIX 4 - LIST OF PANELS

General Info

```
WORK      Anomalies 00
  Prog 08      06.4pH
Sect 07 02.1mS 13:15
GENERAL INFO      C01
```

```
Active Program: 04
  06.3pH 1200W/m2
06.4mS      13:15
SENSORS STATE      C02
```

Program State Consulting

```
Prog 08 ACTIVE
Started by Solar Rad
Repeat 02/05 13:15
PROGRAM STATE      C03
```

```
Prog 08      Ref=06.4pH
S1=05.4PH
S2=05.5PH      13:15
PH STATE      C04
```

```
Prog 08      Ref=02.0mS
S1=02.0mS SIn=03.2mS
S2=02.1mS      13:15
EC STATE      C05
```

```
Prog 08
Irrig=0720Wh/m2
Acc=0720Wh/m2 13:15
SOLAR RAD IRRIG  C06
```

```
Prog 08
Fert=1213Wh/m2
Acc0720Wh/m2 13:15
SOLAR RAD FERT   C07
```

```
Prog 08 Time Y
      Day Y
      Period Y 13:15
WORK TIME COND      C08
```

```
Prog 08 Priority 05
Conflict Programs 02
              13:15
PRIOR & CONFLICTS  C09
```

```
Prog 08 IRRIG
Set 01:15:20+005:55
Done 00:45:10 13:15
IRRIG STATE      C10
```

```
Prog 08
+010%
+00:05:55 13:15
SOL RAD EXTENT    C11
```

```
Prog 08
+015%
+00:05:55 13:15
MAN CORRECTION    C12
```

```
Prog 08
+035%
+12:00:13 13:15
TOTAL CORRECTION  C13
```

```
Prog 08 Sect 21/21
Set 00:10:30+009:45
Done 00:03:10 13:15
SECTOR STATE      C14
```

```
Prog 08 Ref=05.6mS
SoLRad -01.6mS
Input +02.6mS 13:15
EC CORRECTIONS    C15
```

```
Prog 02          Fert 02
      Set 40%
Current 20%      13:15
FERTILIZ STATE  C16
```

```
Prog 08  Agitator 01
Work    00:03      WORK
Pause  00:02      13:15
AGITATOR STATE  C17
```

```
Prog 08          Filter --
Last start Manual
At 28-08 18:32 13:15
PROG LAST START C18
```

Program Settings

```
Between          Prog 07
Date: 01-04      31-10
Time: 07:00      23:00
ACTIVE TIMETABLE S31
```

```
Work day 02      Prog 07
Rest day 03
Weekday SMTWTFS
WORKDAY NNNNNNN S32
```

```
                Prog 07
      Priority 04
Sectors/Group 08
SET PRIORITY      S33
```

```
Time cond y      Prog 07
Solar rad N
Ext tank: -- Link 02
START CONDITION  S34
```

```
Prog 07
07:00  09:20  10:30
12:00  14:00  16:00
SET START TIME    S35
```

```
Prog 07
Repeats 04
  Pause 00:30:00
PROGRAM REPEATS S36
```

```
Prog 07
PreIrrig: 000:00:05
PostIrrig: 000:00:05
PRE/POST IRRIG S37
```

```
Valve 05 Prog 07
Sector 01 Total 03
Value: 00:00:05
SET SECTORS S38
```

```
Prog 07
Fer1=020% Fer2=055%
Fer3=060% Fer4=040%
SET FERTILIZERS S39
```

```
pHRef=07.3pH Prog 07
-00.5pH +00.5pH
Alarm threshold: 02
pH CONTROL S40
```

```
ECRef=07.3mS Prog 07
-00.5mS +00.5mS
Alarm threshold: 02
COND CONTROL S41
```

```
Manual +050% Prog 07
SolRad irrig +010%
CORRECTIONS S42
```

```
Prog 07
Level: 0350W/m2
Accumul: 2500Wh/m2
SOLAR RAD IRRIG S43
```



```
Pre      00:33   Prog 08
Work     00:10
Pause    00:05
SET AGITATORS          S45
```

```
Link 05      Filter 01
Clean on alarm: Y
Clean time: 01:01:02
FILTERS CTRL          S46
```

Controller State Consulting

```
Low level fert: 4
ACTIVE Alarm
26-12 14:36:22 13:15
ALARM 02/07      C25
```

```
Low level fert: 4
CLEARED ALARM
26-12 14:36:22 13:15
ANOMALY 0193/22  C27
```

Controller Settings

```
Log consulting date:
      26-12
                        15:05
VIEW LOG DATE          C26
```

```
Date: Fri-22-09-2000
Time: 17:03:20
                        17:03
SET DATE & TIME       S30
```

```
Ctrl in Pre/Post Y
Use acid in pHCtrl Y
pH CTRL OPTIONS      S51
```

```
Ctrl on pH alarm: Y
Irrig on pH alarm: Y
  Ctrl on EC alarm: Y
ALARM BEHAVIOR      S52
```

```
Volume control: N
  Time control: Y
IRRIG CTRL MODE    S53
```

```
Channel: 01
Now: 02.3 Ref: 02.5
Status: First Stage
CALIBRATE SENSOR  S54
```

```
PH Cfg      EC Cfg:
SensNr=02   SensNr=03
SDif=03.2   SDif=03.3
SENSORS CONFIG S55
```

```
Flow=010L      Sect 01
Pump flow=000100L
L/impulse=060
SET FLOW PARAMS  S56
```

```
PHk=01.0   ECK =01.3
PHTi=10.0   ECTi =10.0
PHTd=00.5   ECTd =00.5
SET PID PARAMS  S57
```

```
Start delay: 03s
  Stop delay: 03s
  Time cycle: 02.0s
SET TIMINGS      S58
```

```
Recording level: 03
Consulting level: 03
SET LOG LEVELS   S59
```

```
Disable password: N
New password: ---
SET PASSWORD      S60
```

Statistics Consulting

```
From: 09-26 13:37;12
0007654L
                                13:15
TOTAL ACCUMUL      C19
```

```
From: 09-26 13:37;12
000:00:25   Prog   01
Activations 03 13:15
PROGRAM ACCUMUL   C20
```

```
From: 09-26 13:37;12
000:00:17   Sect  01/01
                                13:15
SECTOR ACCUMUL    C21
```

```
From: 09-26 13:37;12
05.3pH
06.7mS      13:15
TOTAL AVERAGES    C22
```

```
From: 09-26 13:37;12
05.3pH      Prog   01
06.7mS      13:15
PROGRAM AVERAGES  C23
```

```
From: 09-26 13:37;12
05.3pH      Sect  01/01
06.7mS      13:15
SECTOR AVERAGES   C24
```

Controller Logging

```
Ext state:ACTIVE
Prog State changed.
18-08 15:05:30 15:05
Log 0012 Lev 03 C28
```

Manual Commands

```
Active program: 03
Start program: -- ?

PROG MAN START S47
```

```
Active program: 03
Stop program: -- ?

PROG MAN STOP S48
```

```
STOP - WORK
WORK -
INIT -
CONTROLLER STATE S49
```

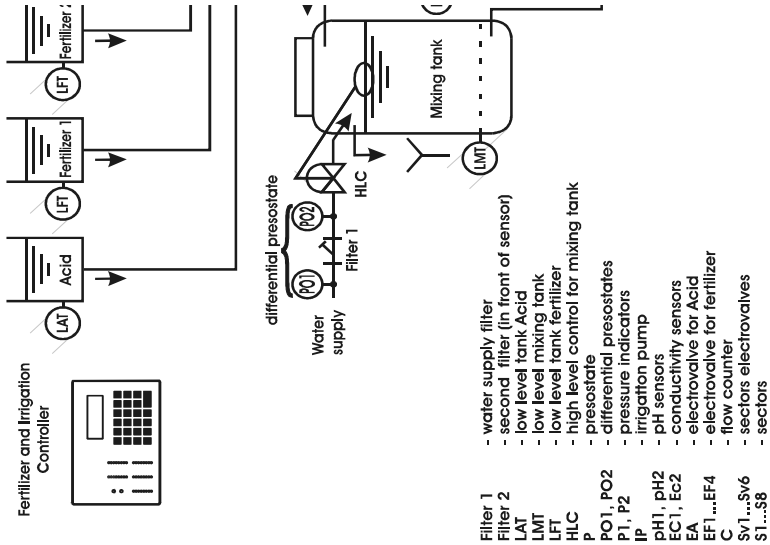
```
Number: 27
Opened: Y
Value: -
OUTLET MAN CTRL S50
```

```
Erase all: -
On overflow: Y
Daily at hour: 00:01
ERASE STATISTICS S61
```

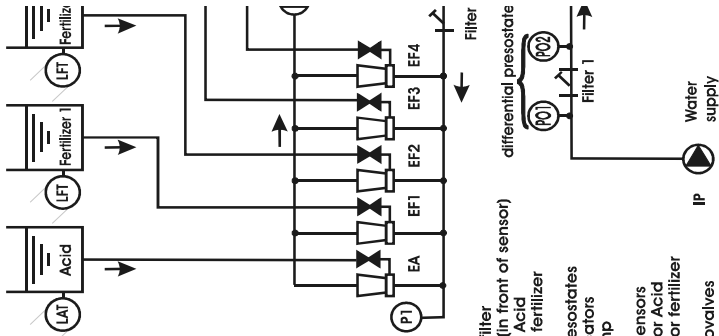
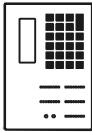
```
Erase program: --
Erase all programs -

ERASE SETTINGS S62
```

APPENDIX 5 - INSTALLATION BLOCK DIAGRAM



Fertilizer and Irrigation Controller



- water supply filter
 - second filter (in front of sensor)
 - low level tank Acid
 - low level tank fertilizer
 - presostat
 - differential presostates
 - pressure indicators
 - irrigation pump
 - pH sensors
 - conductivity sensors
 - electrovalve for Acid
 - electrovalve for fertilizer
 - flow counter
 - sectors electrovalves
 - sectors
- Filter 1
- Filter 2
- LAT
- LFT
- P
- PO1, PO2
- P1, P2
- IP
- PH1, PH2
- EC1, EC2
- EA
- EF1...EF4
- C
- SV1...SV6
- S1...S8
- Water supply
- IP
- Filter 1
- differential presostat

WARRANTY

All Hanna controllers are **warranted for two years** against defects in workmanship and materials when used for their intended purpose and maintained according to instructions.

Damages due to accident, misuse, tampering or lack of prescribed maintenance are not covered. This warranty is limited to free of charge or replacement of the meter only, if any malfunctioning is due to manufacturing defects.

If service is required, contact the dealer from whom you purchased the instrument. If under warranty, report the model number, date of purchase, serial number and the nature of failure. If the repair is not covered by the warranty, you will be notified of the charges incurred. If the instrument is to be returned to Hanna Instruments, first obtain a Returned Goods Authorization Number from the Customer Service department and then send it with shipment costs prepaid. When shipping any instrument, make sure it is properly packaged for complete protection.

Recommendations for user

Before using this product, make sure that it is entirely suitable for the environment in which it is used.

Operation of this instrument in residential area could cause unacceptable interferences to radio and TV equipment.

Any variation introduced by the user to the supplied equipment may degrade the instrument's EMC performance.

Unplug the instrument from the power supply before replacing the fuse or making any electrical connections.

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Hanna Instruments reserves the right to modify the design, construction and appearance of its products without advance notice.

MAN8001
07/03



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