Application Note

BRTSYS_AN_036

IoTPortal Hydroponics Application

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The purpose of this document is to provide an example of the IoTPortal system being utilized for the monitoring and control of a hydroponics application.

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1 Overview

BRTSys IoTPortal is a flexible sensing, monitoring, and control system leveraging IoT to increase efficiency and optimize resource usage across a wide variety of processes and applications. Designed to be quickly and easily deployed, one application well suited to the IoTPortal is managing a Hydroponics system for agriculture.

Hydroponics applications rely on water-based nutrient mineral solutions instead of soil as the basis for growing plants. Controlling the nutrient mineral solutions and environmental conditions accurately is key to ensuring efficient crop yield and plant growth, tight regulation of several parameters is thus required for system optimization. Automating the sensing and control of parameters such as the water pH range, nutrient mix, Dissolved Oxygen (DO) and Grow Lamps can be easily achieved with the IoTPortal and LDSBus devices without the need for specialized hardware and software.

Several parameters must be monitored to successfully grow plants in a hydroponics environment, the most important parameter is the nutrient solution mix. To control this requires the combination of different concentrations of nutrient solutions in the correct ratio. In this application, two tanks of nutrient solution and raw water (to mix) are available. To control the nutrient solution mix accurately, two dosing pumps are used, along with a third pump for the water circulation system. The nutrient mixing ratio will be monitored using Electrical Connectivity (EC) and pH sensors. Thermocouple and DO sensors will also be utilized to monitor the solution temperature and dissolved oxygen value. Temperature, humidity, and CO_2 (Carbon Dioxide) values within the hydroponics environment are also monitored through a CO_2 sensor, whilst the pump and grow light control is achieved using LDSBus 2CH Relays.

Figure 1 below shows the configuration of a typical hydroponics system, in which setup, IoTPortal will be utilized to automate the system.

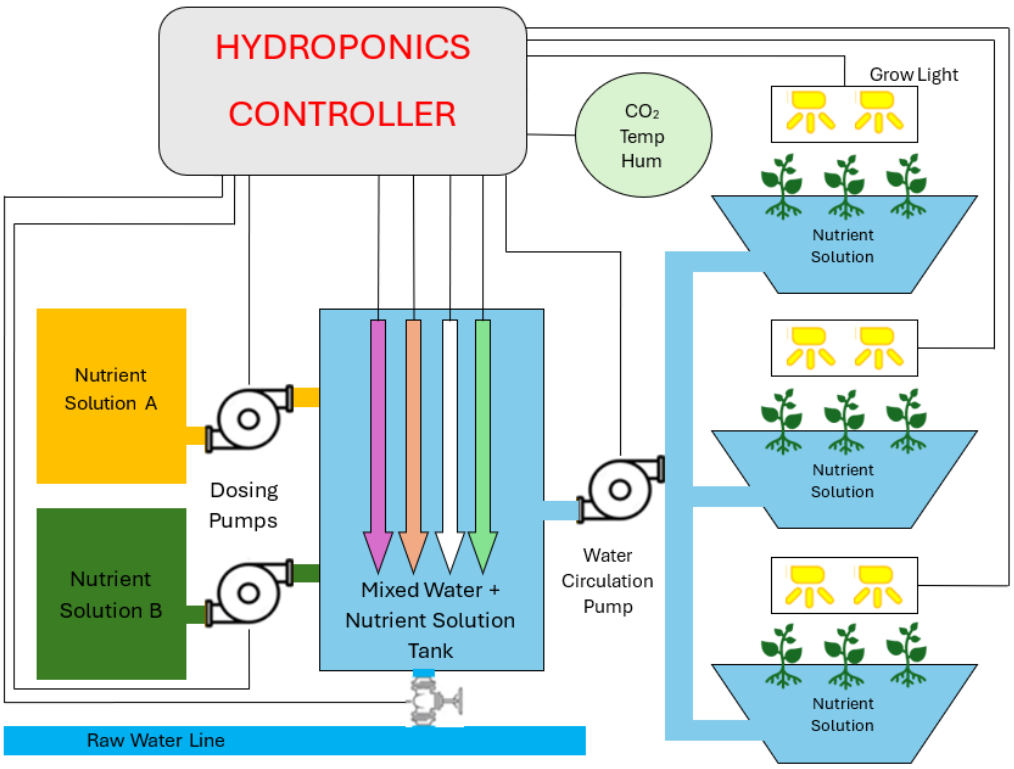

Figure 1 – Hydroponics System Diagram

2 Sense – Hardware & System Overview

This section covers the sensing component of the IoTPortal, and the associated hardware required to perform sensor readings with the system for this application. It also includes an overview for the hydroponics application and details on what environmental parameters are to be monitored.

2.1 Hardware

The IoTPortal Gateway provides the ability to monitor a wide variety of parameters through its included LDSBus ports and associated LDSBus sensor and actuator modules. Table 1 contains a list of the hardware components included within the Hydroponics example:

Device Description	Quantity
IoTPortal Gateway	1
LDSBus EC (Electrical Conductivity) Sensor Adapter	1
Electrical Conductivity Probe	1
LDSBus CO_2 Sensor	1
LDSBus 2CH Relay + iSENSE	2
LDSBus pH Sensor Adapter	1
pH Probe	1
LDSBus Thermocouple Sensor Adapter	1
Thermocouple Probe	1
LDSBus Dissolved Oxygen Sensor Adapter	1
Dissolved Oxygen Probe	2
LDSBus Quad T-Junction	2
Nutrient Dosing Pump	2
Water Pump	1
LED Grow Light	1

Table 1 – Hardware

Note: The quantity of grow lights can vary across hydroponics applications and generally requires one light for each growing tray utilized.

2.1.1 LDSBus Topology

In this application, a single IoTPortal gateway is utilized along with several sensors and actuators to monitor and control various parameters within the hydroponics system. The sensors and actuators can be connected to any of the three available LDSBus ports on the gateway and are daisy chained through 2 Quad T-Junctions. Port 3 on the gateway is utilized in this example and the system topology can be seen in Figure 2 below:

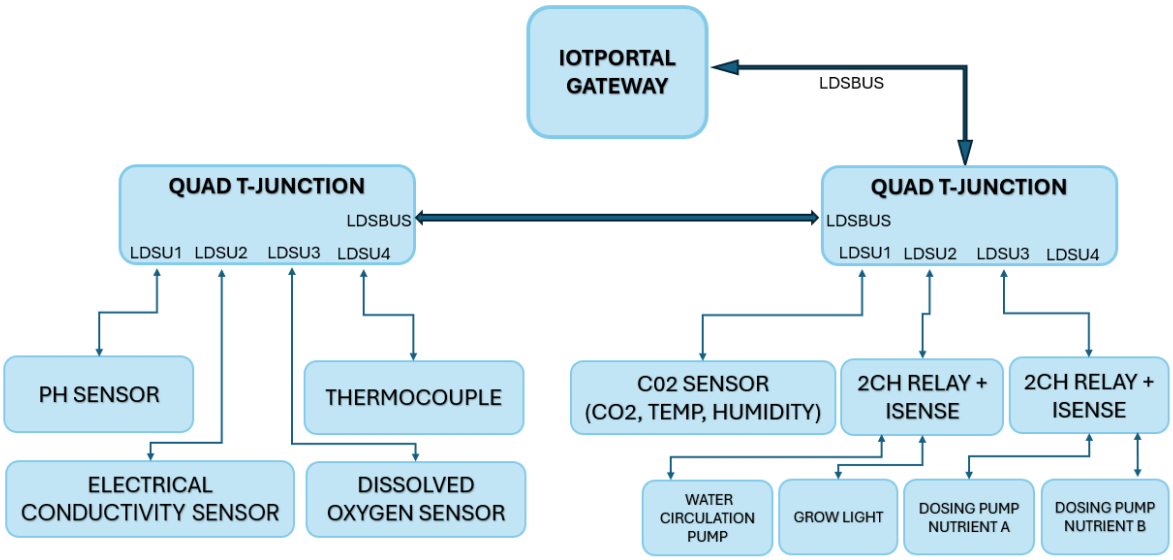

Figure 2 – LDSBus Topology Diagram

2.2 Hydroponics System

Utilizing the IoTPortal system to implement a hydroponics application provides many benefits to the user, but the main benefit of this approach is the ability to implement a complex sensing and control network without the need to deploy a custom software solution. The IoTPortal system allows users to monitor data captured live from their system from anywhere in the world through the associated mobile and desktop applications. The web management console (WMC) or smart phone applications allow users full control over their system by enabling the configuration of actuator events based upon sensor inputs allowing automated control over various system parameters. Events and notifications can also be configured to alert users when predefined parameter thresholds have been reached.

Table 2 below defines the specification for the various parameters which are to be monitored within the hydroponics system for example, including their minimum, maximum and typical values:

Parameters\Range	Minimum	Typical	Maximum
pH	5.5	6.2	7.0
EC	0.8mS/cm	1.2mS/cm	1.8mS/cm
Temperature (Air & Water)	17DegC	25DegC	28DegC
CO_2	600ppm	800ppm	-
Humidity	50%	-	85%
DO	-	above 5mg/L	-
Water Pump Cycle time	-	15Min ON, 15 Min OFF	-
LED Grow Light (PPFD) Early stage (Week 1 - Week 2)	-	500 µmoles/m^2/s [18 Hrs ON and 6 hrs OFF	-
LED Grow Light (PPFD) Mid-Late stages (Week 3 – Harvest)	-	500 µmoles/m^2/s [12hrs ON and 12hrs OFF	-

Table 2 – Hydroponics System Specification

The implementation of this hydroponics system application with the IoTPortal is comprised of four main components, each component is crucial to the success of the system and is achieved using various LDSBus sensors and actuators. These components will be detailed in the following sections.

2.2.1 Nutrient Mixing

A critical factor of a successful hydroponics system is the water based nutrient solution mix, and the ability to precisely control this nutrient mix. Nutrient A and B form a 2-part nutrient system that contains Calcium, Nitrogen, Phosphorus, Potassium, and other minerals essential for healthy plant growth. These nutrients are mixed in water by two dosing pumps (100mL/min) controlled via dosing automation events in the IoTPortal. To achieve this, the system utilizes pH, and Electrical Conductivity (EC) sensors to monitor water nutrient levels and the dosing pumps are controlled by a 2CH Relay controller. The iSENSE variant of the 2CH Relay is used to measure the current consumption of the pumps. When the pH level falls below the minimum threshold, dosing occurs automatically until pH reaches the upper threshold.

2.2.2 Water Circulation System

An automated water circulation system is implemented using a water pump controlled by another 2CH Relay Controller. This maintains optimal conditions for plant growth, by ensuring that water refreshes across different layers of the basin, providing sufficient nutrients and oxygen to the roots of the plants in the hydroponics system.

2.2.3 Grow Light Control

Grow lights are an important component to any hydroponics application to ensure optimal photosynthetic energy is available to support photosynthesis in plants, especially when the hydroponics installation is indoors and there is limited natural light available. The required Photosynthetic Photon Flux Density (PPFD) varies at different growth stages and the grow lamp's Photosynthetic Active Radiation (PAR) is adjusted using a PPFD meter at the various stages. The grow lamp switching is controlled by the IoTPortal via an LDSBus 2CH Relay + iSENSE controller.

2.2.4 Environmental Measurements

General environmental measurements are important to understanding the effectiveness of any hydroponics application. The system utilizes a CO_2 sensor to monitor the plant growing environment CO_2 level, Temperature and Humidity to ensure the conditions are suitable for plant growth.

3 Monitor – Dashboard

This section details how the IoTPortal Dashboard can be utilized to monitor parameters on the system via the associated sensing network.

3.1 Web Management Console

The Web Management Console allows users to monitor various sensor and actuator states using configurable graphs on the WMC dashboard. This dashboard can be accessed through the web application or mobile applications for IoTPortal and is the primary way users can view system data. An overview of the dashboard can be seen in Figure 3 below:

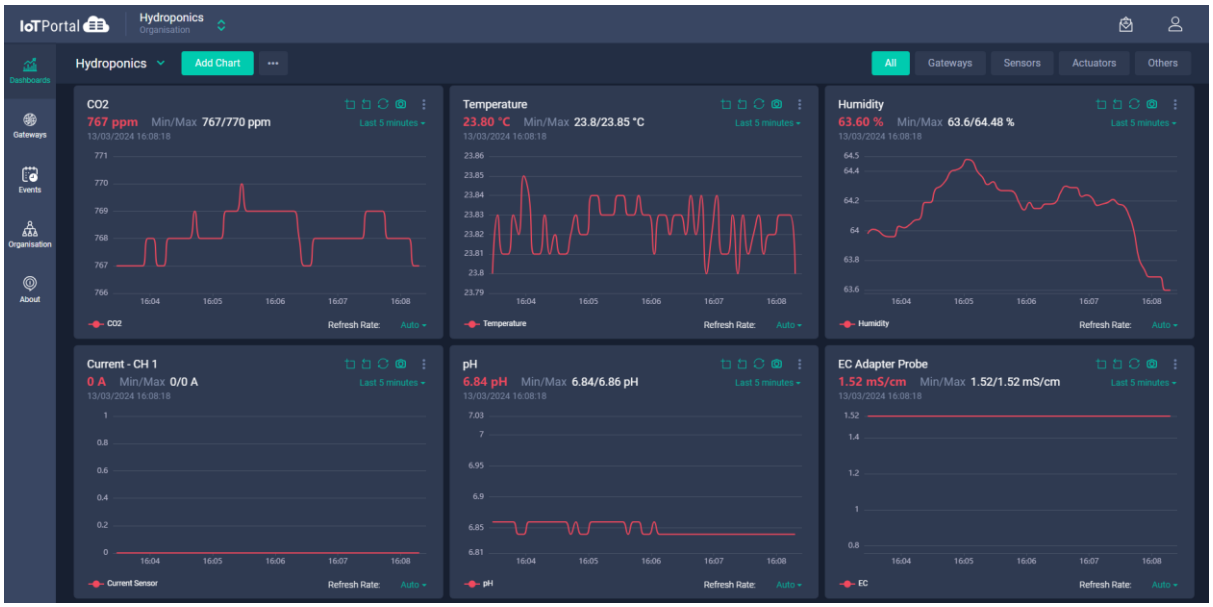

Figure 3 – IoTPortal Dashboard Overview

For this hydroponics application the following graphs have been configured to view on the dashboard for the sensors connected to the system:

- $C0_2$
- Temperature
- Humidity
- pH
- EC
- Thermocouple
- DO

There are also several actuators included in the system which control the various pumps and grow lights configured for use. These lights and pumps are controlled using a 2CH relay which also has current sensing functionality, thus current draw for a given actuator can also be graphed and included on the dashboard. The actuator graphs included are as follows:

- Water Pump state + current
- Grow Light state + current
- Dosing Pump A + current
- Dosing Pump B + current

In case of reading drift or change in the probe, sensors may be calibrated. Sensors can be calibrated using the BRTSys's LDSBus Configuration Utility Tool. Please refer to LDSBus Configuration Utility Guide for the calibration procedure.

4 Control – Events, Automation & Alerts

This section details how the IoTPortal system is utilized to effectively control parameters within the system based upon sensor and actuator inputs via Events and Automation. Details are also provided on how to configure system alerts for users.

4.1 Events and Automation

IoTPortal is a Zero-Code based solution allowing users to control system parameters without the need for custom programming. Event conditions may be configured based on sensor readings or based on absolute time or on a recurrence basis. These events can be used to automate the system functionality and increase the overall efficiency of the system. In this application, several events have been configured to control the nutrient dosing pumps, water circulation pump, and grow light times based upon the specifications defined in the previous section.

An example of event automation can be seen in Figure 4 below, where the event is configured to enable the CH1 of the 2CH relay (connected to Dosing Pump A) based upon three logical AND conditions, whereby if these three conditions are met simultaneously the event will trigger. The first condition enables this event to run all day, the second condition triggers when the EC sensor reading drops below a given threshold (1.8 mS/cm and remains for 30 sec) and the final condition triggers when the pH readings rise above 7 from the connected pH sensor (Rises above 7 pH and remains for 20 sec). Once all these conditions are met, the event triggers the actuator to enable the dosing pump in 40 second intervals for 3 minutes total.

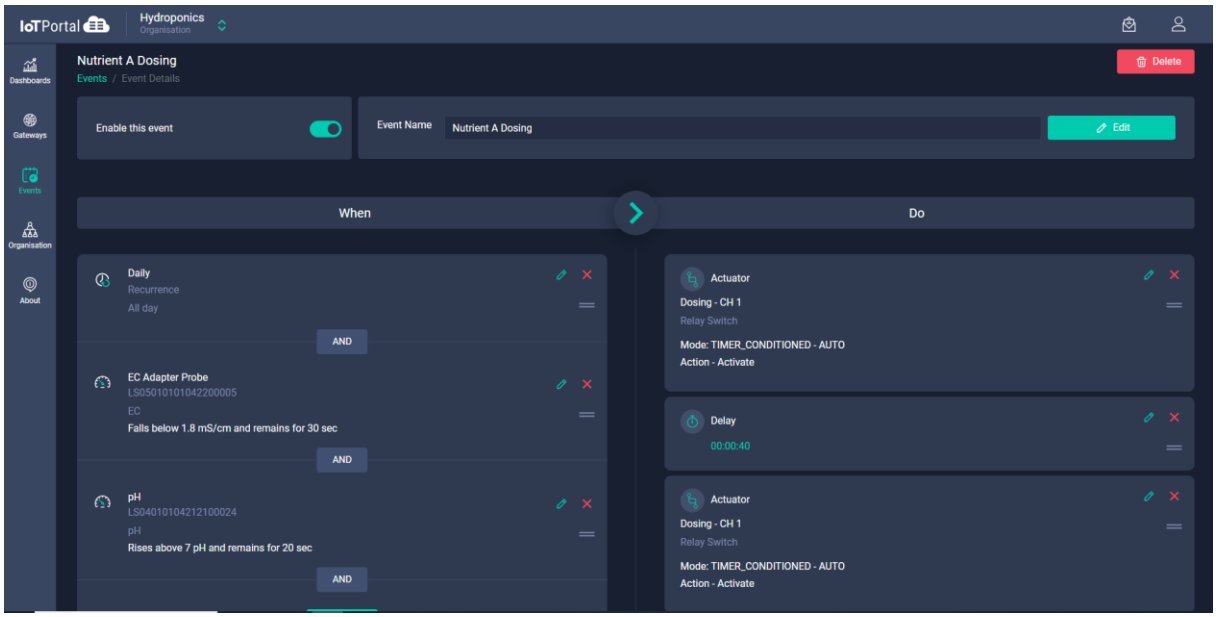

Figure 4 – IoTPortal Dashboard Overview

Figure 5 shows the applicable sensor readings related to this event as graphed on the IoTPortal dashboard. Looking at this figure we can see that the EC reading at 9:00 AM is below the 1.8 mS/cm threshold required by our configured event. Simultaneously the pH reading has reached the threshold required to trigger the associated dosing pump event.

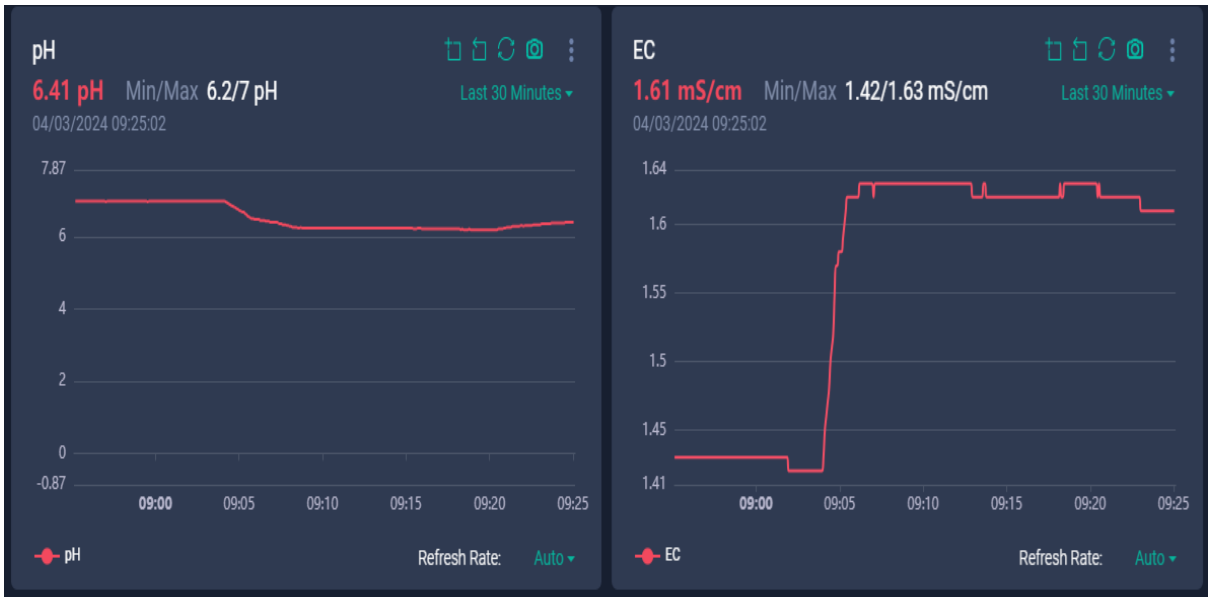

Figure 5 – Sensor Readings for Auto Dosing

Figure 6 shows the dosing pump activation status as graphed on the IoTPortal Dashboard, where 0 indicates the pump is OFF and 1 indicates the pump is ON.

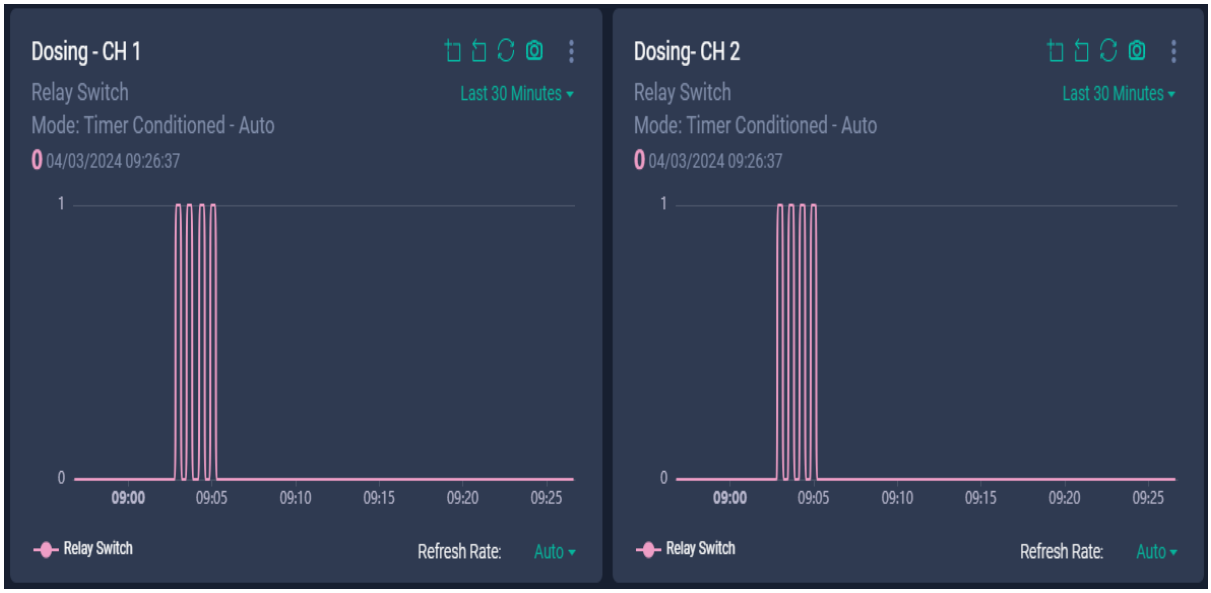

Figure 6 – Dosing Pump Actuators

Referring to both Figure 5 and Figure 6 above we can see that once the event thresholds were met the dosing pump was activated as per the configured event at 9:02AM, this leads to an increase in the EC value being measured by the system by 9:05AM and similarly we see the PH reading drop to 6.2 by the same time once the dosing pump event has completed. This shows that automated events can be utilised to control the nutrient mix level within the hydroponic system automatically, leading to increased system efficiency and better resource utilisation.

Similar events have been configured within the hydroponics application to control the water circulation pump and the growth lights to maintain the perfect environment for plant growth within the hydroponics application.

The IoTPortal Events feature provides farmers who are utilising hydroponics to grow crops with the ability to configure 'grow recipes' for different stages of plant growth based upon system inputs. These recipes could, for example, alter nutrient pump dosing activation times or grow light activation

times based upon current vegetation profiles. Automation of growth profiles and stages in this manner allows precise control over parameters during the full growth stage automatically whilst minimizing the need for manual intervention. This frees the farmer to carry out other tasks whilst monitoring the growth process via the IoTPortal Dashboard. Events are set up using an intuitive graphical user interface and each event can be easily enabled and disabled as required for the different stages of the growth cycle.

4.2 System Alerts

System alerts can also be configured to alert users to potential issues within their system, or when user intervention is required perform routine maintenance on the system. Table 3 below details the alerts that have been configured for this Hydroponics application, and user actions if applicable based on these alerts.

Parameters/Range	Alert Threshold	User Action
PH range	7.0 above	Top up nutrient
EC	1.8 mS/cm above	Change water
Temperature	Below 17DegC or above 28DegC	Set Environmental conditions
CO_2	600 ppm below	Set Environmental conditions
Humidity	85% above	Set Environmental conditions -
Pump Cycle time	No current	Inspect Pump

Table 3 – System Alerts

Figure 7 shows an event alert which has been configured to send an email to a given user if the dosing pump 2CH relay controller goes offline for more than 300 seconds. This alert will allow the system user to inspect any issues with the dosing pumps before they negatively affect plant growth.

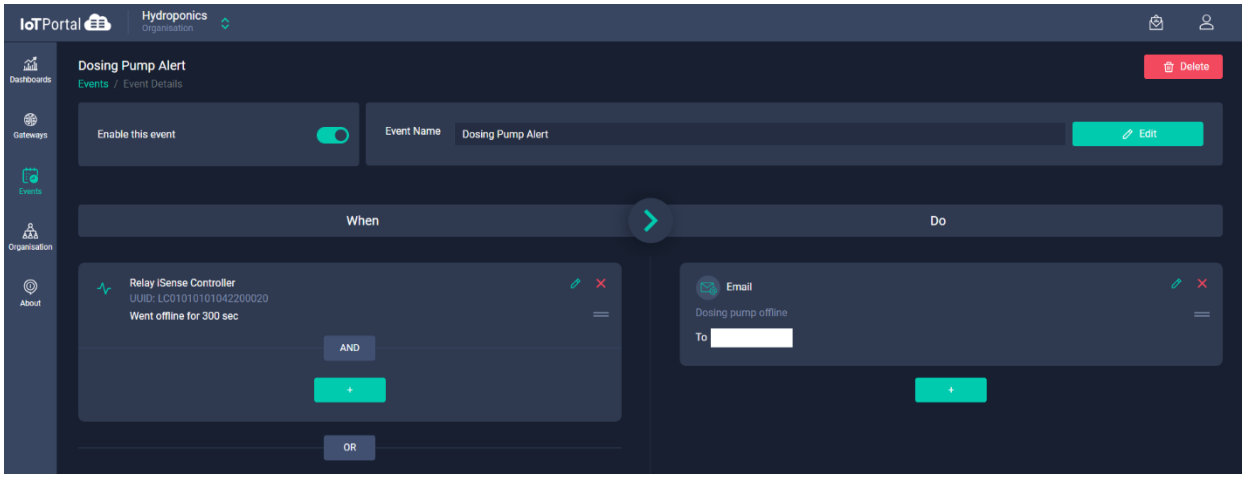

Figure 7 – Dosing Pump Alert

Alerts can similarly be configured to send SMS text messages or push notifications to users to alert them of any potential issues with their system.

5 Conclusion

The IoTPortal system and associated LDSBus sensors and actuators present an ideal solution for implementing automated control over a Hydroponics application. This solution allows users to monitor a wide variety of parameters associated with the application without the need to develop a custom software application. Automated events based upon sensor inputs can be used to trigger actuators and maintain predefined system specifications. Events can also be utilised to alert users when the system may require maintenance or replenishment. These automations via IoTPortal frees up manual labor to be deployed to more strategically important tasks or reduce labor cost.

5.1 Future Improvements

One of the important factors in a hydroponic environment is environmental control. Currently the Hydroponics application does not have any control over environmental conditions such as air temperature and humidity. These are however monitored by the system, in future a control method for these variables could increase the efficiency and yield from the hydroponics application. The hydroponics system could be placed within a greenhouse environment, allowing further control over environmental factors such as humidity (via a humidifier), Air Temperature via opening and closing ventilation, misting of plants with adjustable vapor pressure via controlling fans and misters, and CO_2 levels can be controlled by wood or charcoal burners to further enhance environmental control.

Vapor Pressure Difference is an important factor to consider for plant growth, whilst not currently considered by this application it is supported by IoTPortal and could be incorporated into a Hydroponics system. Additionally, a Nutrient Dosing control event based on the Hydroponic reservoir Capacity and dosing pump rate could be included to increase system efficiency.

Finally, the nutrient solutions Dissolved Oxygen levels are also monitored, and an alert is associated to its threshold levels, but no control is currently enabled for this parameter. An event could be configured to enable additional water pumping out with the standard water circulation pump when the Dissolved Oxygen drops below acceptable levels, as this will increase the DO levels.

6 Contact Information

Refer to https://brtsys.com/contact-us/ for contact information.

Appendix A – References

Document References

LDSBus_Configuration_Utility_Guide

https://brtsys.com/resources/

IoTPortal Android Mobile App User Guide

IoTPortal iOS Mobile App User Guide

Portal Web Application (WMC) User Guide

Acronyms and Descriptions

Terms	Description
CO_2	Carbon dioxide
EC Sensor	Electrical Conductivity
IoT	Internet of Things
LDSBus	Long Distance Sensor Bus
LDSU	Long Distance Sensor Unit
WMC	Web Management Console
2CH Relay	2 Channel Relay + iSense
pH	Potential of Hydrogen
ppm	Parts Per Million

Appendix B – List of Figures and Tables

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Appendix C – Revision History

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Product Page: https://brtsys.com/

Document Feedback: Send Feedback

Revision	Changes	Date
Version 1.0	Initial Release	12-08-2024