AquaMon Precision Agriculture System

A Discussion of the Operation of AquaMon Nodes and RSVP Cloud Application Software

Note: This document discusses common applications for AquaMon nodes and the RSVP (Remote Sensor Viewing Platform) cloud application. Numerous other sensors and application not specifically described are also supported.

Introduction

Contemporary growers can benefit significantly by using sensor data on soil, weather and equipment conditions to optimize crop yields and manage resources such as power and water. However, according to the latest USDA Census on Agriculture only about 10% of growers utilize sensor readings for irrigation and crop management. A significant factor in the low utilization of this technology is the inconvenience of accessing the data and the difficulty in presenting the sensor data in a useful format.

Automating the process of collecting sensor data increases the amount of data available to the grower increases and facilitates more informed decision making. The AquaMon nodes collect a variety of sensor data and transfer that data via the cloud to a secure web server. Once on the server, the data can be processed and posted allowing access from any browser equipped computing or mobile device.

The AquaMon system by Cermetek allows the sensor data to be presented to the grower in a clear, concise manner. RSVP web based application displays the data on any Internet enabled computer or mobile device anytime, anywhere. Further, the grower can access electromechanical devices, such as pumps and valves, to turn them on or off; or to monitor filter status to optimize performance; or to monitor canal water levels – all from within the RSVP application.

Figure 1: AquaMon System Block Diagram

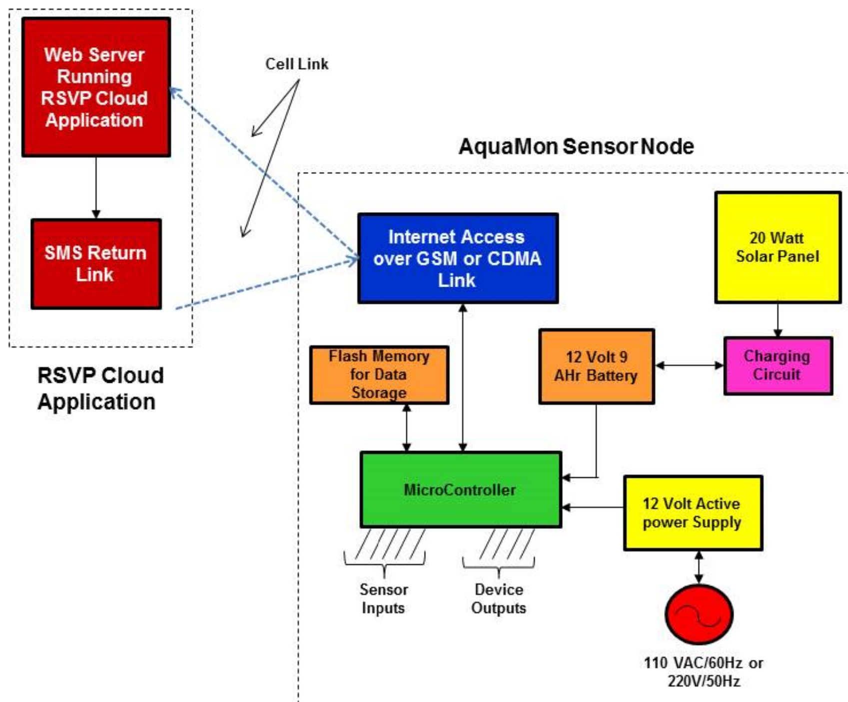


Figure 1 contains a simplified block diagram of the AquaMon system. This block diagram illustrates the basic functional elements of the AquaMon system. The AquaMon sensor node is a microcontroller based system. Embedded code within the microcontroller oversees the collection of data and the communication of that data to the server. Data passes to the server over an integrated GSM or CDMA cellular terminal. Power to the system is provided either from a 12 Volt adapter (when AC power is available) or through a battery with an optional solar power charger.

The critical element of the AquaMon system is the RSVP cloud application running on our secure web server. RSVP provides 100 percent of the user interface for AquaMon. The versatile user interface allows growers to select how they wish to view the field data, set data limits, and define the actions to be taken when those limits are reached or exceeded. After field installation of the AquaMon sensor node, the grower never needs to physically interact with the AquaMon sensor node.

AquaMon Sensor Node Hardware

The AquaMon sensor node hardware is comprised of four subsystems: the controller board, the sensor board, the cellular terminal and the power source. Figure 2 is a photograph of a typical AquaMon node. A NEMA enclosure is used to provide both security and moisture protection and houses the node circuitry.

The controller board is home to the microcontroller which oversees the operation of the sensor node. The sensor board provides the mechanical and electrical interfaces to the specific sensor suite. The sensor board is electronic circuit board visible in the center of the node pictured in Figure 2. The cellular terminal provides the communications link with the web server and it resides above the sensor board. The power source, either battery or AC adapter, provides node power. In Figure 2, the battery power source is positioned in the NEMA enclosure below the sensor board. The controller board is not visible as it is located behind the sensor board.

Figure 2: AquaMon Sensor Node

Controller Board

The brain of the controller board is 16-bit microcontroller. It executes embedded code to collect sensor data, direct communications with the web server, and manage power consumption. The microcontroller utilizes Flash memory for the embedded operating code and cache storage of the sensor data. The microcontroller provides a variety of inputs, outputs and serial ports to interface with a wide array of commercially available sensors as well as the cellular terminal. The controller board contains all necessary electrical connections for the cellular terminal, sensor board and for power. Table 1 lists the major capabilities of the microcontroller.

Table 1: Microcontroller Capabilities

Architecture	16-Bit	
Processing Power	16 MIPS	
Memory	16 KBytes RAM 128 Kbytes Flash; minimum 10,000 read/write cycles	
Power Consumption	Run Mode: 16 mA Standby Mode: 2.5 µA Sleep Mode; 100 nA	
Input/Output Lines	Analog Inputs	10 Bit Analog to Digital Convertor Range 0 to 2.5 Volts 500,000 Samples Per Second 16 Analog Input channels
	Digital Inputs	1 Dedicated Digital Inputs 28 Programmable Digital Inputs/Outputs
Serial Ports	1 USB V2.0 1 RS232C 3 SPI	

Sensor Board

The sensor board provides the physical and electrical interface between the sensors and the microcontroller and it accommodates sensors whose electrical characteristics prevent a direct connection to the microcontroller. A common example would be adapting a sensor with a 5 volt output range to interface to the microcontroller analog input which has a 2.5 Volt input range. Currently, sensor boards have been created to support gypsum block and capacitive moisture sensors, pressure sensors and switches, leaf sensors, and temperature sensors.

The sensor board also adapts to the serial interfaces commonly used for agricultural sensors: SDI-12, RS232, and RS485. The SDI-12 interface typically supports sensor stacks providing readings of soil temperature, moisture, and salinity from multiple depths. The RS232 interface commonly communicates with an attached weather station. Through the RS232 port the weather station passes volumes of environmental data including, temperature, humidity, rain, wind, and barometric pressure. Handling all of these sensor inputs through one serial port rather than individual inputs simplifies data collection.

In addition to providing the interface for system inputs the sensor board also interfaces to system outputs for control of equipment connected to the AquaMon node. These digital outputs toggle high or low to activate and deactivate the connected equipment such as pumps and valves.

Node Power

The single largest consumer of power in the AquaMon node is the cellular terminal. The terminal uses up to 1 Amp of power during communications with the server. To insure the node has adequate power Cermetek offers power supply options. Primary power for the node may come from and a variety of AC adapters or batteries. Offering these options insures the flexibility needed to support the AquaMon nodes operating in a variety of conditions.

To connect to AC power Cermetek utilizes an AC adapter rather than an on-board power supply. There are two reasons for this choice: An external AC adapter permits the AquaMon node to be used in countries that use power standards other than the 120V, 60 Hz standard used in the United States. Using an external AC adapter also insures the safety of the AquaMon nodes by keeping high voltages out of the AquaMon enclosure. An available back-up battery allows the AquaMon node to continue operation for up to 24 hours during power outages. The battery is automatically recharged when power is restored.

When AC Power is not available, the AquaMon node relies on a 12 Volt battery as its primary power source. Normally, a 9 Amp-hour battery is used, but batteries up to 35 Amp-hours may be used depending upon the application. The number and type of sensors and the frequency of sensor data transmission to the server affect the battery requirement. A solar panel is included with battery powered AquaMon nodes. Cermetek employs a 20 Watt solar panel to charge the 9 Amp-hour battery. A larger solar panel may be selected to maintain the charge when a higher capacity battery is used.

RSVP Web Server Application

The RSVP cloud application software runs on the Cermetek virtual web server. RSVP performs the following basic functions: processes sensor data; communicates with the AquaMon nodes; and provides the grower with a method to control/configure the field deployed AquaMon nodes from the Internet.

A single RSVP account allows the Grower access to all his AquaMon nodes. Below is a partial list of the features and capabilities incorporated into the RSVP cloud application.

- Manages communications with the AquaMon nodes.
- Receives sensor data from the AquaMon nodes.
- Processes the data from the AquaMon nodes into a useful database.
- Makes that data available to the grower in the grower's choice of format, see Table 2.
- Permits the grower to define nodes, describe sensors, set data limits for critical parameters and to set sampling rates.
- Transmits Text and/or Email alerts when critical parameters exceed the grower's preset data limits.
- Transmits control signals to the AquaMon nodes to activate remote equipment such as pumps and valves.
- Provides the grower with full control over access to his nodes and his data including password control and full database download.

Table 2: Sample RSVP Data Display Formats

		
Dashboard	**Chart**	**Table**

System Operation

This section briefly describes each of the primary AquaMon functions. These functions are broadly divided into four categories: data collection; communications with the server; grower controls; data alarms and alerts.

Data Collection

The AquaMon nodes collect sensor data based on grower input using the RSVP cloud application. Within RSVP, the grower sets how frequently he wants to read the sensors. RSVP transmits the instructions to the AquaMon node via an SMS (Short Message Service) message. At the prescribed intervals the sensor node reads the sensor values and caches these values as data records in the microcontroller flash memory. The AquaMon node then initiates a cellular link to the web server and transmits the data records in a TCP/IP packet to the server. Upon receiving the data packet from the AquaMon node, RSVP stores the data in the Cermetek database within the grower's account.

The database files are organized as virtual sensor nodes. This architecture allows multiple data records, such as those received from weather stations, SDI-12 sensor arrays and other sensors that are physically connected to a single node to be displayed as multiple nodes for ease of data review and analysis. The virtual node configuration concept is unique to RSVP.

Communications

The AquaMon system utilizes multiple communications paths to execute its functions. The node controls transmission of the sensor data over the cellular link to the server. RSVP sends configuration and control messages to the node as SMS (Short Message Service) messages. Use of the SMS format eliminates the need to have the Cellular terminal on all the time thus saving power. RSVP also transmits Emails and Text messages to individuals as alarm notifications when data limits are exceeded. These alerts are sent as directed in the grower's node configuration.

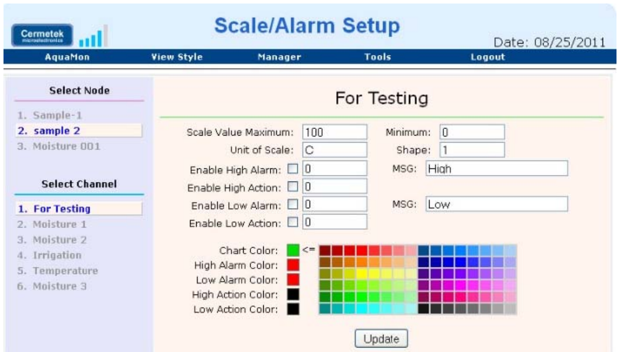
Grower Controls

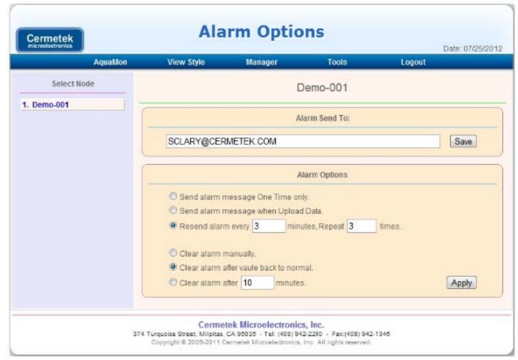
The RSVP cloud application provides the grower with control over all functions of the AquaMon system. RSVP utilizes intuitive, user friendly pull-down menus to exercise this control. In addition, the grower controls the User Names and Passwords so as to limit access to the AquaMon nodes and associated data. To view the sensor data, the grower selects both the display format and the time period of interest. The grower also has the ability to label each node, virtual node, and sensor to simplify data monitoring. RSVP allows the grower to set limits for any parameter the grower deems critical and to issue alarms if those limits are breached. The grower specifies the notification destination of those alarms.

Data Alarms and Alerts

As described earlier, RSVP provides the grower with the tools to set data limits and issue alarms when the data exceeds specified limits. Using the Scale/Alarm selection under the "Manager" pull-down menu, the grower can set the alarm limits for any sensor: it could be a freeze temperature, an irrigation line pressure, or soil moisture value. With the limits set, the grower establishes the actions to be taken when the limits are breached using the "Alarm Options" selection under the "Manager" pull-down menu. Figure 3 shows the RSVP screens used for configuring alarms. In this case, the grower selects how many alarms will be sent, to whom alarms will be sent and how frequently alarms will be sent.

Figure 3: Configuring Alarms on RSVP





Summary

RSVP facilitates the contemporary growers' use of sensor data to optimize crop yields and more effectively manage resources. The AquaMon nodes collect data from a wide variety of sensors including analog, SDI_12 and RS232 based sensors. The RSVP cloud application makes it easy to utilize the sensor data that is collected. The additional data AquaMon and RSVP make available to the grower allows the grower to make more informed farming decisions.

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