Server Control Software
White Paper
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Regardless of the application, most industrial UPS customers require some degree of customization for a particular situation. It might be as simple as adding an analog meter or two (for quick visual reference), or a full-on tailored system designed to mate up with a client's unique electrical requirements. Recently, AMETEK Solidstate Controls received a request from a pipeline customer that went beyond even their usual level of customization (which is quite high) that encompassed all new hardware, software and system design to meet the rigorous specification. The result was an entirely new family of products.

Customization is nothing new to most UPS manufacturers; however coming out of the other side of development with a new product line is not as common. Let's start at the beginning with the customer's needs.

The Situation

Pipeline customers operate in a fairly unique set of circumstances. First, many of their applications are remote, rugged environments. A remote pumping station by nature is not located in an enclosed facility or near other operations. Many times a UPS application is designed to install in a room designed to house electronics and other switchgear. It may be climate controlled (certainly the battery room would be) and located on site close to some type of process control, lighting and/or safety system in a production facility.

Pipelines are different. Most remote pumping stations are in hard to reach, unforgiving areas, away from the populous and removed from other processes and/or facilities; inherent in their name, they are remote. Add to that the wide temperature swings, humidity and sometimes corrosive environments, and you have an application where failure rates are typically can be higher, and when failures do occur they are very costly.

During a power outage or severe power quality deterioration, pipelines and pumping systems must enter into safe network shutdown procedures. These protocols are controlled by various servers that monitor and control the system parameters; however, some clients have reported that due to server errors, their systems did not operate correctly by following pre-determined protocols for powering down. This custom UPS developed by AMETEK Solidstate Controls was designed to allow pipeline customers greater monitoring and control of their systems during a power outage, or power quality issue, and ensure proper shutdown protocols are followed; greatly reducing the opportunity for system failures.

These clients came to AMETEK Solidstate Controls to develop new software integrated into the backup power/power quality systems (UPS) to remedy this problem.

The Analysis
During analysis of the unsafe network shutdown procedures, engineers noted that when the UPS approached the system design life of the backup battery duration and eventual power loss, many if not all of the control systems deployed at a pumping station and/or pipeline control mechanism malfunctioned. This malfunction was determined to be caused by the servers either not sending the proper shutdown communications prior to loss of power, or obviously sending no communications at all after power was lost.

This is an unacceptable situation, as improper sequencing of the pump valve shutdown protocols can lead to huge problems such as auto shutdown valves not activating and in turn, causing a rupture in the lines.

The Solution
AMETEK engineers determined that the UPS system could monitor the battery time remaining and control server shutdown protocols based on real time information of true battery life. It was the lack of information surrounding estimated battery life which was responsible for the system errors as servers lost power before commencing a shutdown of the pump systems. Calculating battery time left is essential for creating dynamic protocols for safe shutdown communications from control system servers.

The new software package allows users to program in battery specifications and calculates in real time, the estimated battery time remaining during the UPS backup operation (battery discharge cycles). The UPS communicates constantly with all servers in the circuit and if a backup power situation arises, the UPS will determine when, and in what sequence the servers are to power down. The UPS sends shutdown messages to the servers; this allows sufficient time for the servers to commence the safe shutdown procedures and eliminating errors caused by servers simply losing power.

As a failsafe mode, the UPS also times out servers based on a pre-determined time interval to eliminate any chance of premature server power failure.

The System
The new UPS software has many features to help operators maintain control of complex remote pumping stations including:

- The ability to store up to 2,000 data events
- The communication of customer-defined alerts pertaining to data log storage (for example and alarm can be configured to alert operators when a certain percentage of the data log is full)
- The ability to retrieve data over Ethernet
- Scheduled equalization of the station batteries
- Constant “heartbeat” monitoring of all servers in the circuit and reporting of server status
- Control of up to four groups of four servers (16 total)
- The ability to dedicate static IPs for all servers
- Time syncing the UPS to NTP (Network Time Protocol)
- Two network adapters (redundancy and signal isolation)
- Ability to test and initiate shutdown of the servers from the front panel of the UPS
- Retrieval of the Data Log over TCP/IP using a web interface

The system network architecture is shown in Figure 1.

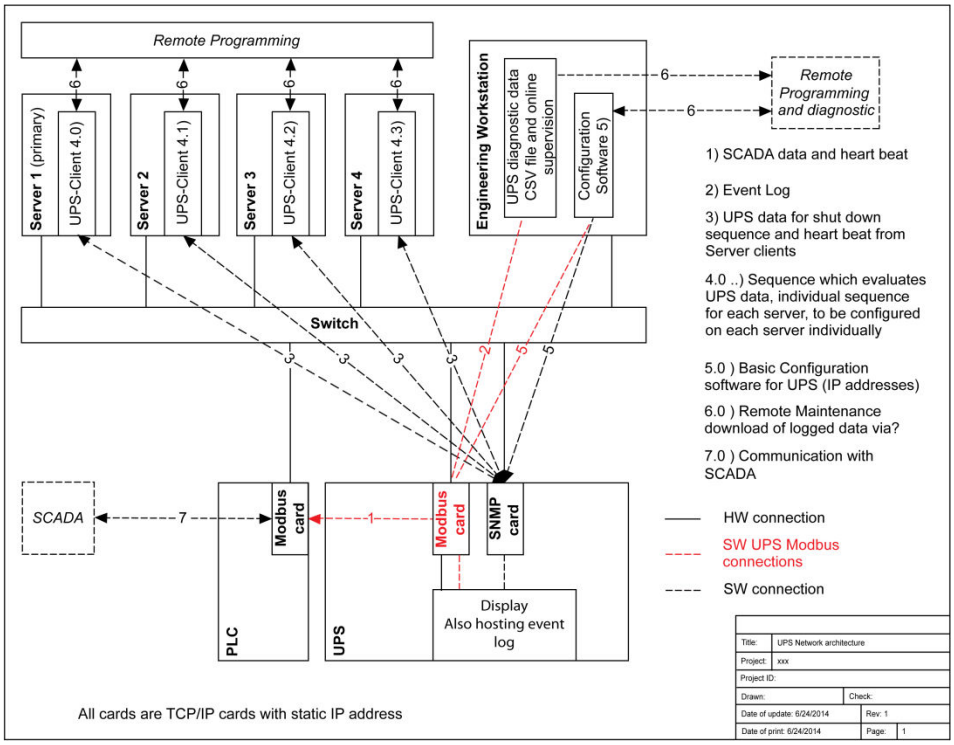

Figure 1 – System architecture including Network Adapter1, 2, Ethernet Switch, Workstation and Remote Servers.

Extended Features and Network Services for AMETEK DPP units include Network Services over two Ethernet ports and additional functions for the UPS. One of the two Ethernet ports is located on the Display Board of the UPS and the other on the Network Adapter which is mounted inside the UPS. The Ethernet port on the Display Board is referred to as Network Adapter 1 and the Ethernet port mounted inside the unit on the right hand side is referred to as Network Adapter 2.

Capabilities of Network Adapter 1

- Viewing and retrieval of Data Log over Ethernet
- Modbus TCP messages
- Viewing system parameters and status

Capabilities of Network Adapter 2

- Shutting down servers
- Heartbeat messages from the client running on the servers to Network Adapter 2
- Ability to test shutdown from the front panel
- Synchronization of UPS time to NTP server
- SNMP messages

Accessing Web Pages on the Network Adapters

Both network adapters utilize web servers and associated web pages resident in each adapter's software to facilitate presentation of UPS information and management of the adapter. Both adapters provide a 100-baseT Ethernet port that supports TCP/IP. Accessing the web pages for each is similar, with a couple of differences. Network adapter 1's home page displays graphically the operation of the UPS below in Figure 2.

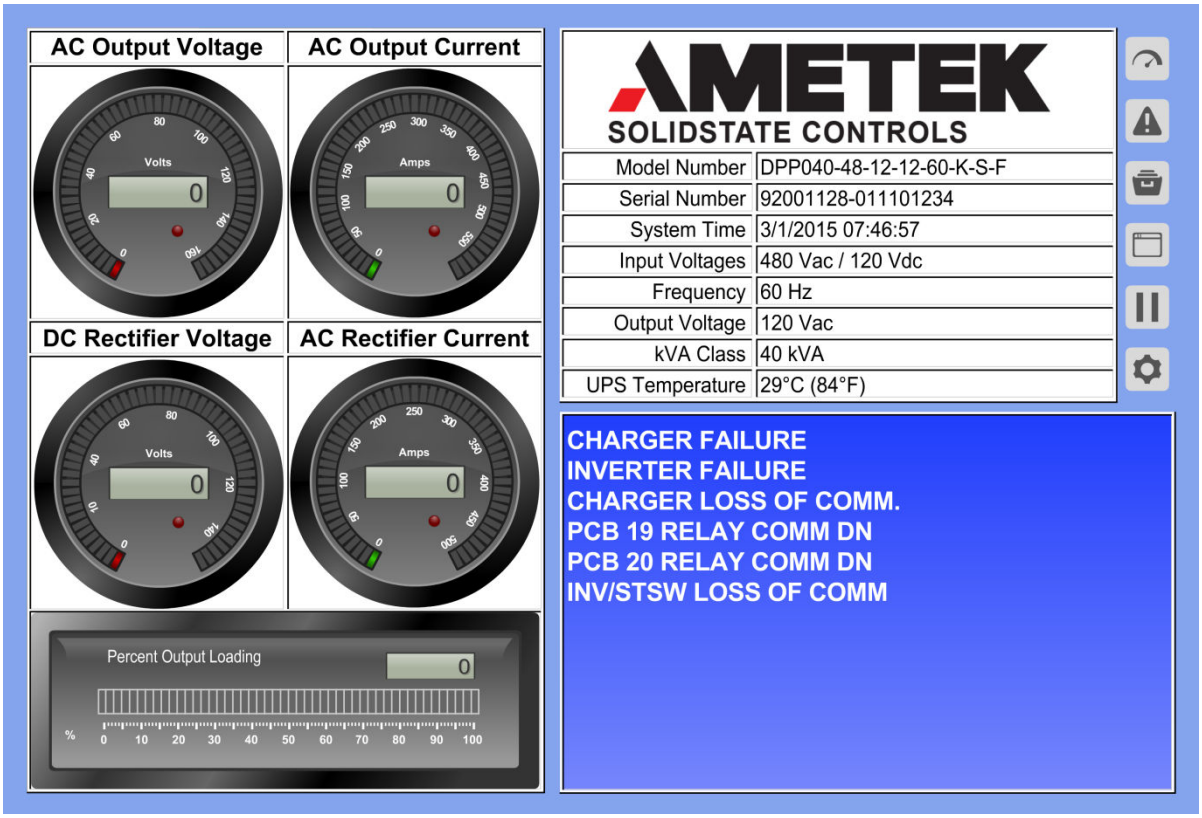

Figure 2 - Home Web Page of Network Adapter 1

For Network Adapter 2, the messaging is more text driven as seen in Figure 3.

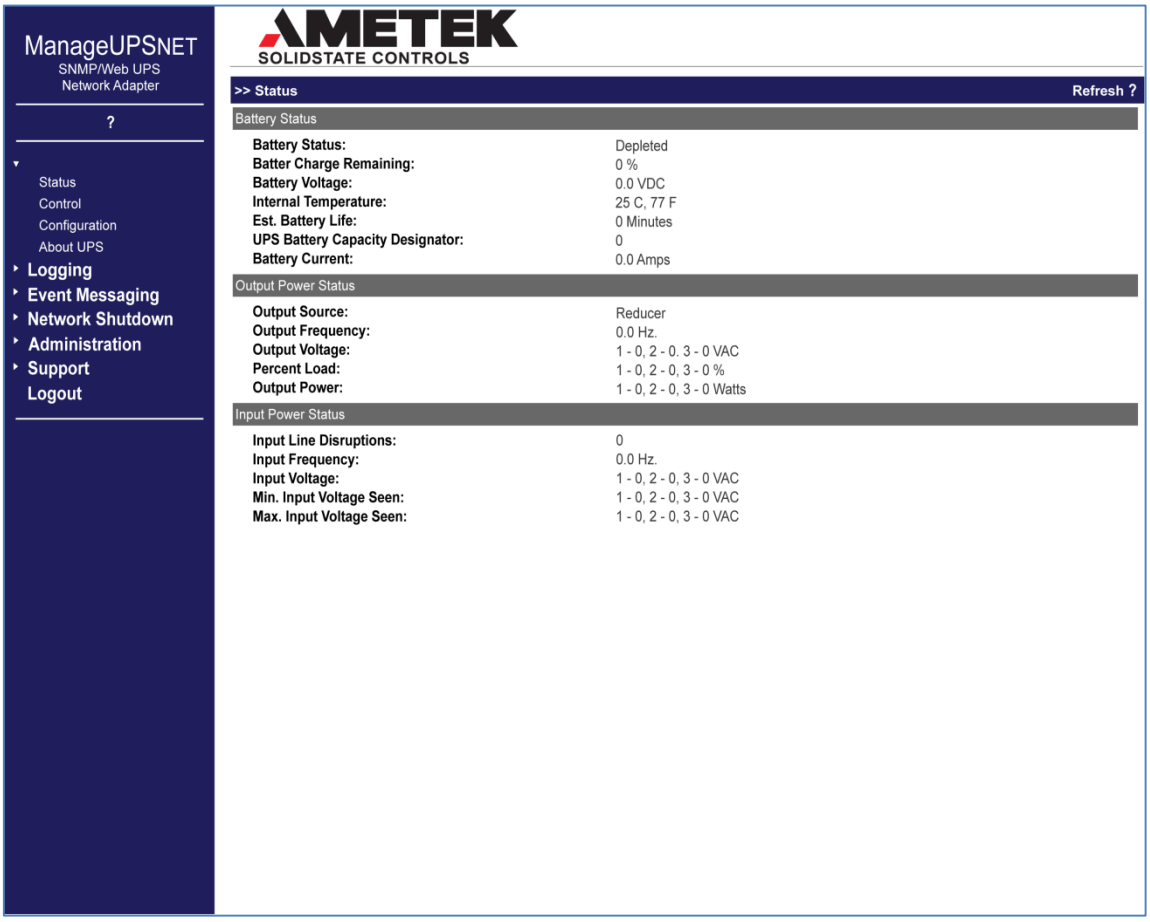

Figure 3 – Example of Home Web Page of Network Adapter 2

Setting Network Parameters for Ethernet Adapters

Network Adapter 1 is located on the UPS Display Board. Connection is made directly to the RJ-45 connector. If the adapter is set up to use dynamic addressing using DHCP, the assigned IP address and settings will be displayed on the UPS display's Network Settings page once it connected to an IP network and the settings shave been assigned as shown in Figure 4.

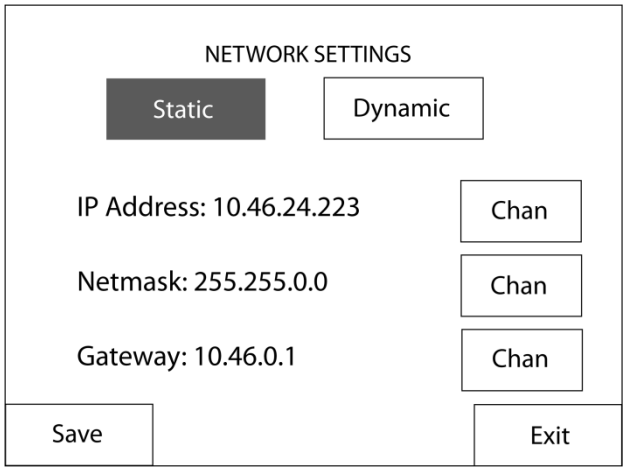

Figure 4 – Network Settings Page for Network Adapter 2 on the UPS Display

Server Shutdown by UPS

Server shutdown is facilitated by the software running on Network Adapter 2 and additional software running in the background on servers to be shut down.

Configuration information for the servers and associated shutdown criteria is entered and saved on one of the web pages of the software. Information is entered for each server up to a total of 16 servers. The software on Network Adapter 2 sends a shutdown message to a server when the UPS is running on batteries and the shutdown time criteria have been met. The application will respond with message indicating that the impending shutdown request was successfully processed and will shut down the server shown in Figure 5.

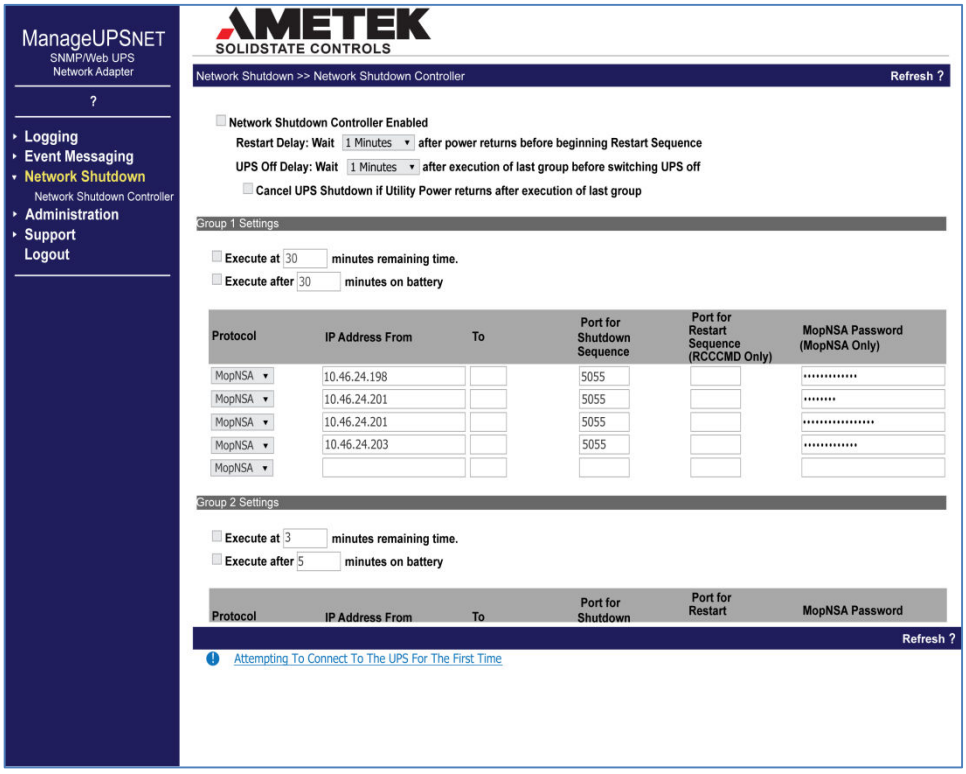

Figure 5 – Network Shutdown Controller Page for Network Adapter 2

Heartbeat Communication Message
A timeout function is provided for communication between Network Adapter 2 and the MopUPS application running on the server. The communication consists of a heartbeat message the MopUPS software sends to Network Adapter 2. If the heartbeat message is not received after a period of more than 30 seconds, a Server Timeout alarm is generated for that server. The Server Timeout alarm is the indication that communication has been lost with the MopUPS client running on the server.

Time Synchronization of UPS to NTP Server
Network Adapter 2 provides the means to synchronize the UPS. The software on the adapter synchronizes the software on adapter 2 and also synchronizes the clock on the UPS's display board. In the event that communication fails with the NTP server and displays a drift of more than 5 seconds, the time on Network Adapter 2 will be synchronized to the DPP display board since the display board includes a battery backed real time clock and the clock on Network Adapter 2 does not. Once communication has been reestablished with the NTP server, Network Adapter 2 will resynchronize the clock on the display board.

Modbus TCP
Modbus TCP communication is provided by Network Adapter 1. Modbus TCP for DPP supports two Modbus function codes: read holding register and read coil.

Viewing and Retrieval of Data Log over Ethernet
Network Adapter 1 provides a web page that provides for monitoring of the current UPS status and the ability to view and download the Event, Battery History, and Battery Test Logs. The home page of the Network Adapter 1 web page provides an overall status of UPS operations, such as AC output and DC rectifier voltages and currents, an abbreviated alarm status, percent output loading, and UPS manufacturer information. It also provides buttons that will display a comprehensive Measurements Page, a Detailed Alarms page, a UPS Log Page, and other functions.

A comprehensive Measurements Page includes tabs that may be used to select for AC, DC, and miscellaneous readings. Values are displayed graphically as meters, along with the actual values for each measurement.

An Alarms Page displays the UPS alarms, and indicates which alarms are active and which alarms are inactive. Active alarms are displayed with a red background, and inactive alarms are displayed with a green background. All controls are outlined in Figure 6.

Viewing UPS Status and Retrieving Data Log over Network Adapter 1
The Data Log Page provides tabs for viewing the Data Log, Battery History Log, Battery Test Log, and the Datastore. The Data Log displays the events and alarms recorded by the UPS during operation. It can contain up to 2000 entries. Once 2000 entries have been recorded, the log will wrap back and write over the oldest entry first. The control screen and a sample Data Log is shown in Figures 6 & 7.

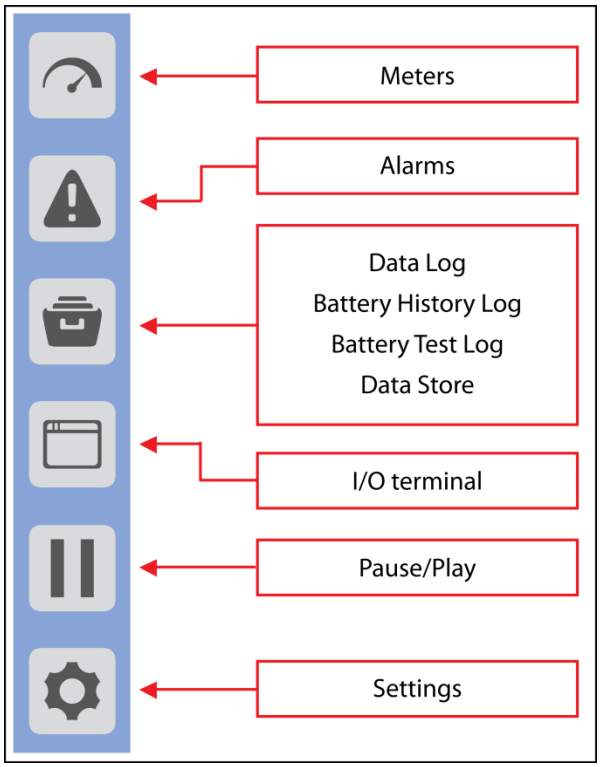

Figure 6 – Definition of buttons on Home Page of Network Adapter 1

Number	Event	Date	Time	
1	FLT Mode Initialized	9/05/2014	13:01:47	View
2	EQU Mode Initialized	9/05/2014	13:01:43	View
3	Battery Charging	9/05/2014	13:01:43	View
4	Battery Discharing	9/05/2014	12:59:52	View
5	Charger Normal	9/05/2014	12:49:08	View
6	Charger Failure	9/05/2014	12:49:07	View
7	Charger Bd. Reset	9/05/2014	12:49:05	View
8	Transfer To Inverter	9/05/2014	12:48:08	View
9	Inverter Normal	9/05/2014	12:47:57	View
10	Battery CB Closed	9/05/2014	12:47:47	View
11	Charger Normal	9/05/2014	12:47:46	View
12	DC Voltage Normal	9/05/2014	12:47:35	View
13	Low DC Voltage	9/05/2014	12:47:33	View
14	System Reset	9/05/2014	12:46:47	View
15	Low DC Voltage	9/05/2014	12:46:03	View
16	Inverter Failure	9/05/2014	12:46:02	View
17	Charger Failure	9/05/2014	12:46:01	View
18	DC Too Low For Start	9/05/2014	12:46:00	View
19	Inverter Low V (fast)	9/05/2014	12:46:00	View

Downloads: Data Log Data Log (Extended) Data Log (CSV) 22 Events Logged

Figure 7 – Data Log Page of Network Adapter 1

There are three additional link types associated with the log pages. The links allow the logs to be opened and viewed in another tab or window of the web browser, and to be saved in a file. The three formats are:

- Log - Contains the event name, date, and time only in text format.
- Log (Extended) - Contains the same information as the standard Data Log as well as system readings at the time the event occurred in text format.
- Log (CSV) - Contains the same information as the Extended Data Log. The data is formatted and comma delimited to be easily imported into a spreadsheet. It may be opened up as a spreadsheet or a text file.

Data Log Full Alarm Set Point (% of log full)

The display software provides an alarm that indicates when the number of events stored in the Data Log has exceeded a pre-defined percentage value. The Data Log Full Set Point is the value at which the Data Log Full Alarm transitions from inactive to active and is specified as a percent of the Data Log size. Valid values for the Data Log Full Set Point are from 10% to 100%. For example, if the Data Log Full set point is set to 20%, the Data Log Full Alarm will go active when the number of events stored in the log since the Data Full Value was reset reaches 400 events. The alarm will go inactive only after the Data Log Percent Full Value is reset.

Resetting the Data Log Percent Full Values does not clear events in the Data Log. It only resets the Data Log Percent Full Value. All events in the Data Log are preserved. The software on the DPP display board does not allow the Data Log events to be erased, only overwritten. Consequently, all events in the Data Log are preserved until overwritten after the log becomes full at 2000 events.
The Data Log Full Alarm is also reflected in the Modbus TCP messages.

Scheduled Equalization of Batteries

The UPS provides the option to schedule the charger to switch the equalize voltage at a predefined interval. The interval is specified in days, from 1 to 730 When going from float to equalize mode, the charger output voltage will change from the float voltage to the equalize voltage for a specified period of time. Equalization is performed at midnight on the day when the interval timer reaches 0 days and the period of time the charger remains in equalize mode is specified in minutes. Once the equalization is complete, the scheduled equalize will wait the number of days in the predefined interval to execute again as shown in Figure 8.

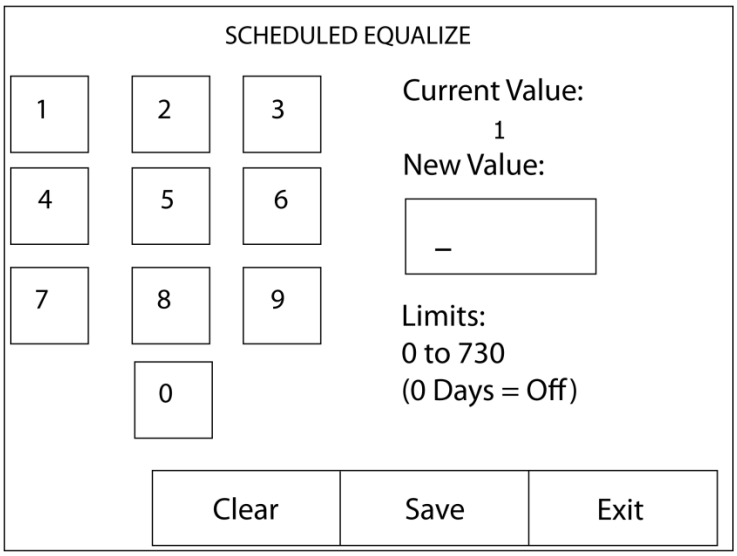

Figure 8 – Scheduled Equalize Page of UPS Display

Summary:

AMETEK Solidstate Control's engineers were able to quickly determine the cause of the errors that occurred during premature power outages that prevented safe pipeline and pumping station shutdown, and develop a new UPS system with failsafe backup power and control mechanisms to keep crucial operations running smoothly, prevent potential costly and disastrous consequences, and increase the level of confidence in all of AMETEK's pipeline customers.