Cellwatch Battery Monitoring System
Application Note
20090425-1-7

Cellwatch MODBUS Gateway Protocol

Guide

This Application Note supersedes and compiles all previous Modbus Application Notes for the Cellwatch system. The superseding application notes are:

- Tech20030128-1-1 – Modbus Functions in Cellwatch
- Tech20011011-1-4 – Cellwatch Modbus Protocol
- Tech20030124-1-1 – Modbus Guidance

This document includes specific changes introduced in Cellwatch 4.1.0 which have been marked as such.

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Contents

Purpose

This document outlines the communication protocol for communication between Cellwatch and third-party building management systems.

Cellwatch utilizes the MODBUS™-TCP protocol as the basis for communicating information from the Cellwatch Battery Monitoring Unit (BMU) to external devices.

Note: This guide may be subject to change with new releases.

Terminology used:

Cell	*A self-contained unit consisting of a single chemical unit for the lead acid chemistry (i.e., 2v nominal)*
Jar	*A self-contained unit containing 2 or more cells.*
String	*A number of cells or jars connected in series*
Battery	*One or many strings of cells or jars.*
System	*The entire array of batteries monitored by one BMU.*
DCM	*Data collection module (Optically isolated device with 4 data channels each). (254 per optical loop)*
CU	*Control unit – BMU communicates via RS-485 to each CU. The CU then converts the RS-485 signal into optical signals and sends the commands to the DCMs on it optical loop. The CU also can handle inputs from 4 current sensors and 4 temperature sensors (up to 4 strings per CU). (Up to 31CU's per RS-485 line)*
iBMU	*Battery monitoring unit (Dedicated Rackmount or Wall-mount unit used to Run the Cellwatch software) which controls all events/alarms. (One per system)*

Modbus Specification

A Cellwatch BMU will purport to be multiple MODBUS devices; Modbus Slave Device 1 for the overall system information (system summary and battery summaries) and Device 2 and up for each string present in the system. (i.e., Device 2 = Battery 1 String 1, Device 3 = Battery 1 String 2, …)

There are two Modbus register maps, one for system level information (Device 1) and one specification for individual string level information (Device 2 and up). Figure 1 – Modbus Device Overview

Strings are assigned unique addresses within the Modbus register based on their organization within the battery configuration. Unless the address for the individual string is 'known', it is recommended to look at the battery name and string name registers for device ID 2 and higher

to identify which battery string you are accessing. This is described in further detail in **Error! Reference source not found.**.

The summary system and battery information can be retrieved from the "system unit" (device 1) and the individual string and cell readings will be retrieved from the subsequent "string units."

NOTE: In the following "specifications" consider the addresses to be in the PLC's 30000 address range (input registers). So, a value would be read using a MODBUS function code 04.

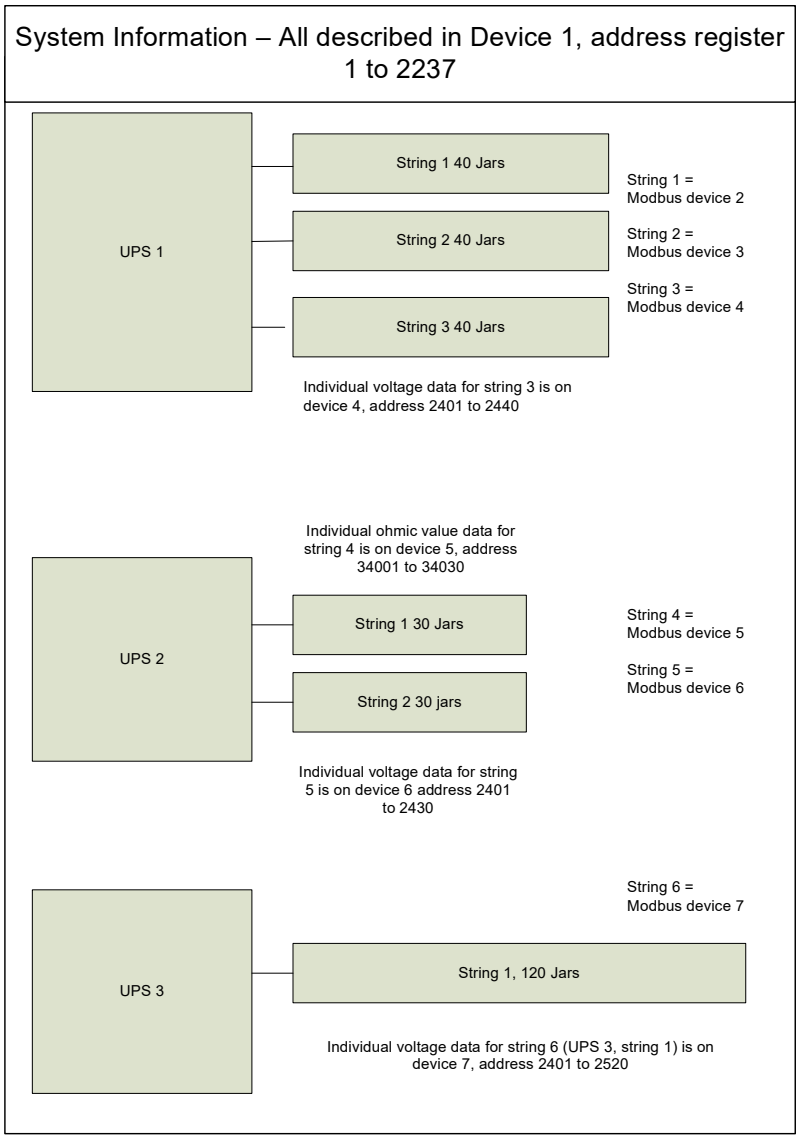

Figure 1 – Modbus Device Overview

General Cellwatch Modbus Notes

- Cellwatch MODBUS communications work on a “polled” basis.
- MODBUS information is only available in RTU (binary) format.
- No more than a maximum of 125 registers per contingent block should be read at any one time.
- Due to recommended security updates from Microsoft, the number of half open TCP/IP connections has been limited to 10. This security measure limits the spread of worms and viruses by limiting the half open connections. For best performance, you should configure your MODBUS polling system to re-use the existing network socket instead of creating a new socket connection.

SCADA & BMS Recommendations

NDSL recommends the following settings for polling MODBUS with a building management system (BMS)

- We recommend limiting the number of client devices (i.e., Modbus polling system) accessing a single IBMU.
- Disable concurrent scanning within the Modbus polling system. Only 1 device ID should be polled at any given time.
- Disable scattered reads.
- A maximum scan rate of 100ms in between polls.
- Recommended retry rate -100ms between retries

System Register Maps:

The system unit contains a system section followed by repeated battery sections, or repeating sets of registers. Only battery sections for the number of batteries on the Cellwatch system are valid, the rest are unused.

Unused or invalid register requests will return **0x8000** for that register value.

*NOTE: Do **NOT** modify the register address listed in this document. Standard Modbus addressing would transmit a request of address of 1 as a request address of 0. (Actual TCP data is ZERO-based while any documentation data is ONE-based.)*

System Overview Information (Device=1)

Reference Data Definitions (Table 1) below

	Description	Starting Offset	Ending Offset	To Get Actual Value
	System Name	1	String(98)=49 registers	
	# of Days System has been scanning (0 if stopped)	50		
	System status	51	See Decoding Status	
Battery Summary	Number of batteries	52		
	Number of strings in system	53		
	Avg. battery current	54		/10
	Avg. battery voltage	55		/10
	Avg. battery temperature	56		/10
	Min. battery current	57		/10
	Min. battery voltage	58		/10
	Min. battery temperature	59		/10
	Max. battery current	60		/10
	Max. battery voltage	61		/10
	Max. battery temperature	62		/10
	System ID	256	String(10)= 5 registers	
	Software Major Version	261		
	Software Minor Version & Release	262		
	Last Discharge Year	384		
	Last Discharge Month	385		
	Last Discharge Day	386		
	Last Discharge Hour	387		
	Last Discharge Minute	388		
	Last Discharge Second	389		

	Last Voltage Scan Year	390		
	Last Voltage Scan Month	391		
	Last Voltage Scan Day	392		
	Last Voltage Scan Hour	393		
	Last Voltage Scan Minute	394		
	Last Voltage Scan Second	395		
	Last Ohmic Scan Year	396		
	Last Ohmic Scan Month	397		
	Last Ohmic Scan Day	398		
	Last Ohmic Scan Hour	399		
	Last Ohmic Scan Minute	400		
	Last Ohmic Scan Second	401		
	Battery Currents (0 - 123)	512	512 + #Batteries - 1	/10
	Battery total Voltages (0 – 123)	640	640 + #batteries – 1	/10
	System Temperature Count	768		/10
	System Temperatures (0 – 123)	769	769 + #Temps - 1	/10
	Battery Status (0-123)	896	896 + #Batteries - 1	
Battery 1	Battery #1 name	1024	String (80)=40 registers	
	Battery Status	1064	See Decoding Status	
	Number of strings	1065		
	First string index	1066		
	Battery current	1067		/10
	Battery total voltage	1068		/10
	Avg. string current	1069		/10
	Avg. string voltage	1070		/10
	Avg. string temperature	1071		/10
	Min. string current	1072		/10
	ID of min. current string	1073		/10
	Min. string voltage	1074		/10
	ID of min. voltage string	1075		/10
	Min. string temperature	1076		/10
	ID of min. temperature string	1077		/10
	ID of min. temperature probe	1078		/10
	Max. string current	1079		/10
	ID of max. current string	1080		
	Max. string voltage	1081		/10
	ID of max. voltage string	1082		
	Max. string temperature	1083		/10
	ID of max. temperature string	1084		
	ID of max. temperature probe	1085		
Ba	Battery #2 name	1408	String(80)=40 registers	

	Battery Status	1448	See Decoding Status	
	Number of strings	1449		
	First string index	1450		
	Battery current	1451		/10
	Battery total voltage	1452		/10
	Avg. string current	1453		/10
	Avg. string voltage	1454		/10
	Avg. string temperature	1455		/10
	Min. string current	1456		/10
	ID of min. current string	1457		
	Min. string voltage	1458		/10
	ID of min. voltage string	1459		
	Min. string temperature	1460		/10
	ID of min. temperature string	1461		
	ID of min. temperature probe	1462		
	Max. string current	1463		/10
	ID of max. current string	1464		
	Max. string voltage	1465		/10
	ID of max. voltage string	1466		
	Max. string temperature	1467		/10
	ID of max. temperature string	1468		
	ID of max. temperature probe	1469		
Battery 3	Battery #3 name	1792	String(80)=40 registers	
	Battery Status	1832	See Decoding Status	
	Number of strings	1833		
	First string index	1834		
	…	…	…	…

String Register Maps:

The string units contain a system section identical to the system unit, a battery section of the same format as the battery sections in the system unit but pertaining only to the battery to which the string belongs, a string summary section, a temperature section, a voltage section, and an ohmic value section.

String INPUT Register Information (Device =2 and up)

Reference Data Definitions (Table 1) below

	Description	Starting Offset	Ending Offset	To get Actual Value
	System Name	1	String(98)=49 registers	

	# of Days System has been scanning (0 if stopped)	50		
	System status	51	See Decoding Status	
System Summary	Number of batteries	52		
	Number of strings in system	53		
	Avg. battery current	54		/10
	Avg. battery voltage	55		/10
	Avg. battery temperature	56		/10
	Min. battery current	57		/10
	Min. battery voltage	58		/10
	Min. battery temperature	59		/10
	Max. battery current	60		/10
	Max. battery voltage	61		/10
	Max. battery temperature	62		/10
	System ID	256	String(10)= 5 registers	
	Software Major Version	261		
	Software Minor Version & Release	262		
	Last Discharge Year	384		
	Last Discharge Month	385		
	Last Discharge Day	386		
	Last Discharge Hour	387		
	Last Discharge Minute	388		
	Last Discharge Second	389		
	Last Voltage Scan Year	390		
	Last Voltage Scan Month	391		
	Last Voltage Scan Day	392		
	Last Voltage Scan Hour	393		
	Last Voltage Scan Minute	394		
	Last Voltage Scan Second	395		
	Last Ohmic Scan Year	396		
	Last Ohmic Scan Month	397		
	Last Ohmic Scan Day	398		
	Last Ohmic Scan Hour	399		
	Last Ohmic Scan Minute	400		
	Last Ohmic Scan Second	401		
	Battery Currents (0 - 123)	512	512 + #Batteries - 1	/10
	Battery Total Voltages (0 – 123)	640	640 + #batteries – 1	/10

	System Temperature Count	768		
	System Temperatures (0 – 123)	769	769 + #Temps - 1	/10
	Battery Status (0-123)	896	896 + #Batteries - 1	
Battery Summary	Battery name	1024	String(80)=40 registers	
	Battery Status	1064	See Decoding Status	
	Number of strings	1065		
	First string index	1066		
	Battery current	1067		/10
	Battery total voltage	1068		/10
	Avg. string current	1069		/10
	Avg. string voltage	1070		/10
	Avg. string temperature	1071		/10
	Min. string current	1072		/10
	ID of min. current string	1073		
	Min. string voltage	1074		/10
	ID of min. voltage string	1075		
	Min. string temperature	1076		/10
	ID of min. temperature string	1077		
	ID of min. temperature probe	1078		
	Max. string current	1079		/10
	ID of max. current string	1080		
	Max. string voltage	1081		/10
	ID of max. voltage string	1082		
	Max. string temperature	1083		/10
	ID of max. temperature string	1084		
	ID of max. temperature probe	1085		
String Summary	String name	1408	String(80)=40 registers	
	String Status	1448		
	String voltage	1449		/10
	String current	1450		/10
	Average cell voltage	1451		/100
	Average cell ohmic value	1452		/1000
	Minimum cell voltage	1453		/100
	ID of min. voltage cell	1454		
	Minimum cell ohmic value	1455		/1000
	ID of min ohmic value cell	1456		

	Maximum cell voltage	1457		/100
	ID of max. voltage cell	1458		
	Maximum cell ohmic value	1459		/1000
	ID of max. ohmic value cell	1460		
	Number jars in thermal warn state	1470	***New in v4.1.0*** Note: Please use the string status register to determine the meaning of the disconnect time.	
	String disconnect year	1471		
	String disconnect month	1472		
	String disconnect day	1473		
	String disconnect hour	1474		
	String disconnect minute	1475		
	String disconnect second	1476		
String Ripple Voltage				
	Ripple Value	1480		/1000
	String Ripple Limit	1481		/1000
String Temp				
	Temperature count	2200		
	Temperature #0	2201	2201 + #Temps - 1	/10
Voltage				
	Voltage count	2400		
	Voltage #0	2401	2401 + #Vs - 1	/100
O.V.				
	Ohmic value count	34000		
	Ohmic value #0	34001	34001 + #Rs – 1	/1000
Individual Cell Temp				
	Cell Temperature count	44000		
	Cell Temperature #0	44001	44001 + #Rs – 1	/10

All string and cell “IDs” are zero-based. String indexes are zero-based relative to each battery. Cell indexes are zero-based relative to each string.

Identifying Cells and their Alarm Limits

For the string units, there is a corresponding address space in the PLC’s 40000 address range (i.e. holding registers) that can be used to obtain the high and low alarm limits set in the system. The string status (offset 1448) must be set to 0 to read the low alarm values and 1 to read the high alarm values. Setting the system status on any string changes the system status for all strings.

The channel starting block number and ending block number (if applicable) is also retrieved from the Holding register address space. If the string status is set to 80hex the voltage registers

(2401+) will return the starting cell/jar number of the associated channel as configured in the Cellwatch system. If the string status is set to 81hex the voltage registers will return the ending cell/jar number, if there is an ending cell/jar number configured for that channel in the Cellwatch system, otherwise UNDEFINED will be returned for the ending cell/jar number.

Use MODBUS function code 06 to set whether the values are high or low alarm limits and MODBUS function code 03 to read the values.

String HOLDING Register Information

	Description	Starting Offset	Ending Offset	To get Actual Value
	High string voltage limit	1449		/10
	Low string voltage limit	1450		/10
	String thermal protection enabled	1470		0 = Disabled 1 = Enabled
String Summary	String thermal V limit	1471		/10
	String thermal T limit	1472		/10

Thermal runaway protection will only show as enabled if user has enabled this in the software and the following requirements are met:

- String is on a thermal controller (TRC)
- String has at least one TP
- String has at least one CT

Data definitions

All register results except strings are returned as 16-bit signed integer values.
The following scaling factors are used:

Table 3

Measurement	Scaling Factor	Units	Example (Returned -> Real)
Temperatures	/10	°C	134 -> 13.4°C
Battery currents	/10	Amps	-240 -> -24.0 A
Battery voltages	/10	Volts	5400 -> 540.0 V
String currents	/10	Amps	400 -> 40.0 A
String voltages	/10	Volts	4800 -> 480.0 V
Cell voltages	/100	Volts	1235 -> 12.35 V
Cell ohmic values	/1000	mOhms	1224 -> 1.224 mOhms

Decoding an ASCII String

Each register in the System/Battery/String Name will return the equivalent of a 4 byte hex number. The value of the high order byte (1st and 2nd hex characters) in the first register is the equivalent of the first ASCII character. The value of the low order byte (3rd and 4th hex characters) is first register is the equivalent of the second ASCII character. See the example below:

Where the battery name is displayed as **Battery: NDSL UPS**

Input Register Address	1024		1025		1026		1027		1028		1029		1030		1031		1032	
Full Data Word (hex)	4261		7474		6572		793A		204E		4453		4C20		5550		5300	
Upper Bytes (Hex)	42		74		65		79		30		44		4C		55		53	
Lower Bytes (Hex)		61		74		72		3A		4E		53		20		50		00
ASCII	B	a	t	t	e	r	y	:		N	D	S	L		U	P	S	###

NOTE: The battery name will always begin with **Battery:** and the string name will always begin with **String:**.

Decoding Status

The Status registers return the low byte of a word that gives the status of the overall system. If a bit is 1, there is an alarm. If a bit is 0, then there is no alarm.

LSB	0	Hardware communications error
	1	Cellwatch not scanning
	2	Temperature alarm
	3	Current alarm
	4	Ohmic Value alarm
	5	Voltage alarm

	6	System alarm – Set if any other bit is set
	7	Thermal runaway condition present
	8	A string has been disconnected (must be reset at breaker and in Cellwatch)
	9	String voltage alarm
	…	
MSB	15	Unused

Thermal Status Bits and String Disconnect Time

New in Cellwatch 4.1.0

Bit #7 – A string is showing thermal runaway conditions
When bit #7 (thermal runaway conditions) is active, one or more jars on the system (battery or string) has a high voltage and temperature reading. This *will* cause the generate system alarm (bit #6) to be solid.

Bit #8 – A string has been disconnected
If a string has been disconnected, then bit #8 will be active, and will remain active until the user clicks the "re-arm" link in the Cellwatch software *even* if the thermal runaway condition has cleared. This bit will cause the system alarm bit (#6) to be active as a reminder that the user should reconnect any disconnected strings.

Bit #9 – String voltage alarm
If the user has configured string voltage level alarms, and this string is in alarm, this bit will be set. If set in a system or battery status register it means that one of the strings under this node is in string voltage alarm.

String disconnection time registers
If the string has thermal runaway conditions (bit #7 ON) but has not yet been disconnected (bit #8 OFF) then these registers show the time in the future when the disconnect relay for this string will be energized.

If the string has already been disconnected (bit #8 ON) then this shows the time in the past when this string was disconnected. Even once the user re-arms this string, the time will still reflect the time it was last disconnected, so the user should always consult bits #7 and #8 to determine the meaning of this time.

Appendix A

Cellwatch Basics

The intent of this section is to explain the basic operations and processes behind Cellwatch to those that are unfamiliar with the Cellwatch Software and its function.

The Cellwatch system has been designed to cope with **any** battery configuration and size. Each Data Collection Module (DCM) has 4 channels, normally one cell or jar is monitored per DCM channel. DCM's can monitor between 2 to 12 volts per channel allowing each DCM channel to span one or several cells or jars. 16-volt jars can be monitored if the 4th channel of each DCM is nulled. 254 DCMs can be connected per Control Unit (CU), creating one optical loop.

The CU converts RS485 signals from the Battery Management Unit (BMU) into optical signals for the DCM's on its optical loop. The DCMs on a CU's loop may be monitoring one or several batteries. Usually, a CU is situated close to the one to four batteries it is monitoring so that the current clamps that run from the CU can access the current carrying cables of the batteries. Temperature Probes can be placed on pilot cells or left in the air to monitor ambient temperatures. This is dependent on customer choice/site.

Normal Operation (i.e., battery on float charge)

During normal operation the Cellwatch BMU monitors voltage of all cells/jars every 1 or 6 hours and the ohmic value of all cells/jars is monitored every 24 or 12 hours.
Current and temperature of all batteries on the system are monitored continuously between and during the voltage and ohmic value scans. Every night at midnight values are averaged and stored in a history file.

Discharge Operation

When a discharge occurs on a battery within the system the relevant current sensor will detect the discharge within a very short time as the BMU is continuously monitoring these sensors. The BMU will then command all the DCMs on that battery to take a "snapshot" of the voltages. The BMU will begin downloading voltage information from each DCM while continuing to monitor all the current sensors on the system. Should any other battery go into discharge, then the same procedure will be performed simultaneously. The discharge file(s) will be saved at the end of the discharge. (I.e., when the current ceases to flow out of the batteries according to the current sensors). A voltage reading is taken on a DCM channel about every 2 seconds.

Post Discharge Charge Operation

When a battery has discharged and the power is restored, the Cellwatch system will rescan the voltage for a period of time that can be configured by the end user. This is to clear low voltage alarms that may have occurred as the cell voltages dropped below the low voltage alarm level, which is intended for low charge alarms. This allows the system to keep up to date due to any rapid changes in voltages over the initial charge-up time. Default times are voltage readings every 10 minutes for one hour after discharge.

Register Reference

This section will outline the data addresses and the information available. All items will use the following format:

Text name (register address) - description

Register	Location	Description
System information		
System Name	*0-49*	This returns the computer name as found in network properties. (See decoding an ASCII string)
System is operating/Scanning	50	Return zero if the application is running but is not scanning or monitoring the batteries. Returns non-zero if the system is operating normally. *NOTE: ALL OTHER VALUES ARE NOT CURRENT IF THIS REGISTER RETURNS ZERO.*
System status	51	Returns a byte (low byte of register word) that gives the status of the overall system. If a bit is 1, there is an alarm. If a bit is 0, then there is no alarm.
Number of batteries	52	Total number of batteries that make up the system.
Number of strings in system	53	Total number of strings that make up the entire system
Avg. battery current	54	Latest average of all battery currents on the system
Avg. battery voltage	55	Latest average of all battery voltages of the system
Avg. battery temperature	56	Average of all the latest average battery temperatures of the system
Min. battery current	57	Latest minimum battery current in the system
Min. battery voltage	58	Latest minimum battery voltage in the system
Min. battery temperature	59	Latest minimum temperature in the system.
Max. Battery current	60	Latest maximum battery current in the system
Max. Battery voltage	61	Latest maximum battery voltage in the system
Max. Battery temperature	62	Maximum temperature in the system
System ID	256	This returns the software name: Cellwatch. (See decoding an ASCII string)
Software Major Version	261	Major Cellwatch Software version. I.E., version 2.72.2 will appear as 2

Software Minor Version & Release	262	Miner Version and Release. I.e. version 2.72.2 will appear as 722
Last Discharge Year	384	Year of last discharge event for any Battery
Last Discharge Month	385	Month of last discharge event for any Battery
Last Discharge Day	386	Day of last discharge event for any Battery
Last Discharge Hour	387	Ending Hour of last discharge event for any Battery
Last Discharge Minute	388	Ending Minute of last discharge event for any Battery
Last Discharge Second	389	Ending Second of last discharge event for any Battery
Last Voltage Scan Year	390	Year of last voltage scan
Last Voltage Scan Month	391	Month of last voltage scan
Last Voltage Scan Day	392	Day of last voltage scan
Last Voltage Scan Hour	393	Hour of last voltage scan
Last Voltage Scan Minute	394	Minute of last voltage scan
Last Voltage Scan Second	395	Second of last voltage scan
Last Ohmic Scan Year	396	Year of last ohmic scan
Last Ohmic Scan Month	397	Month of last ohmic scan
Last Ohmic Scan Day	398	Day of last ohmic scan
Last Ohmic Scan Hour	399	Hour of last ohmic scan
Last Ohmic Scan Minute	400	Minute of last ohmic scan
Last Ohmic Scan Second	401	Second of last ohmic scan
Battery Currents	512 to (512 + Number of Batteries – 1)	Latest current reading (see battery current) for each battery
Battery Voltages	640 to (640 + Number of batteries – 1)	Latest voltage reading (see battery voltage) for each battery.
System Temperature Count	768	Number of temperature sensor configured in system

System Temperatures	769 to (769 + Number of Temperature Sensors – 1)	Latest temperature reading for each temperature sensor in the system
Battery info-		
Battery Base	((Zero-based battery index) * 384) + 1024	Battery base for system slave/unit
All battery specific information begins at the Battery Base.		
Battery base for string slave/unit	1024	
Battery #X name	Battery Base to (Battery Base + 39)	Name of battery as defined in the Cellwatch configuration file. (Max. 80 chars.) (2 chars. per register.)
Battery Status	Battery Base + 40	Current status of this battery. Status follows same format as system status
Number of strings	Battery Base + 41	Number of strings on this battery.
First string index	Battery Base + 42	The Modbus slave / unit ID of the first string on this battery
Battery current	Battery Base + 43	Sum of all the string currents on this battery
Battery voltage	Battery Base + 44	Average of all the string voltages on this battery
Avg. string current	Battery Base + 45	Average of all the string currents on this battery.

() –Avg. string voltage (Battery Base + 46) – Average of all the string voltages on this battery.

Avg. string temperature (Battery Base + 47) – Average of all the temperature sensor reading on this battery.

Min. string current (Battery Base + 48) – Lowest string current (of strings with currents) on this battery.

ID of min. current string (Battery Base + 49) – Zero-based index of battery string that has the lowest current reading.

Min. string voltage (Battery Base + 50) – Lowest string voltage (of strings with cells) on this battery.

ID of min. voltage string (Battery Base + 51) - Zero-based index of battery string that has the lowest voltage reading.

Min. string temperature (Battery Base + 52) – Lowest temperature sensor reading on this battery.

ID of min. temperature string (Battery Base + 53) - Zero-based index of battery string that has the lowest temperature reading.

ID of min. temperature probe (Battery Base + 54) - Zero-based index of the temperature probe that has the lowest temperature reading. (Is on string identified in “ID of min. temperature string (Battery Base + 52)”.)

Max. String current(Battery Base + 55) – Highest string current on this battery.

ID of max. current string (Battery Base + 56) - Zero-based index of battery string that has the highest current reading.

Max. String voltage (Battery Base + 57) – Highest string voltage on this battery.

ID of max. voltage string (Battery Base + 58) - Zero-based index of battery string that has the highest voltage reading.

Max. String temperature (Battery Base + 59) – Highest temperature sensor reading on this battery.

ID of max. temperature string (Battery Base + 60) - Zero-based index of battery string that has the highest temperature reading.

ID of max. temperature probe (Battery Base + 61) - Zero-based index of the temperature probe that has the highest temperature reading. (Is on string identified in “ID of max. temperature string (Battery Base + 59)”.)

String information:-

String name (1408 to (1447)) – Name of this string as configured in the Cellwatch system. (Max 80 chars.) (2 chars. per register.)

String Status (1448) – Status of this string. Same format as System Status.

String voltage (1449) – Sum of all the cell voltages on the string.

String current (1450) – Reading of current probe, if configured.

Average cell voltage (1451) – Average of cell voltage readings in string.

Average cell ohmic value (1452) – Average of cell ohmic value readings in string.

Minimum cell voltage (1453) – Lowest cell voltage reading in string.

ID of min. voltage cell (1454) - Zero-based index of cell with lowest voltage reading in string.

Minimum cell ohmic value (1455) – Lowest cell ohmic value in string.

ID of min ohmic value cell (1456) - Zero-based index of cell with lowest ohmic value reading in string.

Maximum cell voltage (1457) – Highest cell voltage in string.

ID of max. voltage cell (1458) - Zero-based index of cell with highest voltage reading in string.

Maximum cell ohmic value (1459) – Highest cell ohmic value in string.

ID of max. ohmic value cell (1460) – Zero-based index of cell with highest ohmic value reading in string.

String Ripple Value (1480) – Ripple Voltage displayed in mV

String Ripple Limit (1481) – Alarm limit (high) for Ripple Voltage displayed in mV

Temperature count (2200) – Number of temperature sensors in string.

Temperature (2201 to (2201 + Number of Temperature sensors – 1) – Individual temperature sensor readings for string.

Voltage count (2400) – Number of voltage readings on string.

Voltage (2401 to (2401 + Number of voltage readings – 1)) – Individual cell voltage readings for string.

Ohmic value count (34000) – Number of ohmic value readings in string.

Ohmic value (34001 to (34001 + Number of ohmic value readings – 1)) – Individual ohmic value readings for string.

Cell Temperature Count (44000) – Number of Cell Temperature readings in string.

Cell Temperature (44001 to (44001 + Number of cell temperature readings – 1)) – Individual cell temperature readings for string.