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Evaluation of the 8310-N-S Manufactured by Sutron—Results of Bench, Temperature, and Field Deployment Testing

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Abstract

The Sutron 8310-N-S (8310) data collection platform (DCP) manufactured by Sutron Corporation was evaluated by the U.S. Geological Survey (USGS) Hydrologic Instrumentation Facility (HIF) for conformance to the manufacturer's specifications for recording and transmitting data. The 8310-N-S is a National Electrical Manufacturers Association (NEMA)-enclosed DCP with a built-in Geostationary Operational Environmental Satellite transmitter that operates over a temperature range of −40 to 60 degrees Celsius (°C). The evaluation procedures followed and the results obtained are described in this report for bench, temperature chamber, and outdoor deployment testing. The three units tested met the manufacturer's stated specifications for the tested conditions, but two of the units had transmission errors either during temperature chamber or deployment testing. During outdoor deployment testing, 6.72 percent of transmissions by serial number 1206109 contained errors, resulting in missing data. Transmission errors were also observed during temperature chamber testing with serial number 1208283, at an error rate of 3.22 percent. Overall, the 8310 has good logging capabilities, but the transmission errors are a concern for users who require reliable telemetered data.

Introduction

The U.S. Geological Survey (USGS) Hydrologic Instrumentation Facility (HIF) evaluates the performance of instruments and equipment that are used to directly measure hydrologic data. These devices may measure parameters needed to quantify streamflow (such as river stage, water velocity, or water discharge) to monitor groundwater levels or to measure water-quality parameters in a variety of field settings. In addition, the HIF evaluates the performance of instruments and equipment that are used in combination with devices that directly measure hydrologic data. These devices include data loggers and recorders, radios for data telemetry, power supplies, solar panels, batteries, cableway and bridge-measuring equipment, and water-quality sampling devices. The performance of these devices is evaluated in a variety of ways; however, the primary factors evaluated are:

- The manufacturer's stated specifications for accuracy and resolution.
- Any relevant USGS accuracy requirements.
- The ability of the device to operate under a wide range of environmental conditions at remote, unmanned field stations.
- Power source and power consumption.
- Compatibility with existing USGS field hydrologic data-collection infrastructure and equipment.

The evaluations may involve extended operation in one or more field locations and (or) may employ testing chambers designed to reproduce a range of environmental conditions. Instrument and equipment evaluations are done primarily to determine if particular devices would be suitable for use by USGS personnel for hydrologic data collection.

This report describes the procedures followed and the results obtained from the datalogger and Geostationary Operational Environmental Satellite (GOES) radio evaluation testing of a commercially available data collection platform, the Sutron 8310-N-S (8310). For the remainder of this report, the Sutron 8310-N-S is referred to as 8310.

Description of the Sutron 8310-N-S Data Collection Platform

The 8310[1] Data Collection Platform (DCP) (fig. 1) is the successor to the 8210[1] DCP. The 8310 includes a data logger and GOES radio transmitter mounted in a National Electrical Manufacturers Association (NEMA) enclosure. Three 8310 units were tested: serial numbers 1206109, 1208283, and 1208284. Selected manufacturer's specifications for this device (Sutron, 2014) are listed in table 1. The specific model tested was the 8310-N-S, which includes an 8310 data logger and a Satlink2-V2 GOES Transmitter enclosed in a single NEMA enclosure. The 8310 is approximately the same size as the equivalent model of the Sutron 8210, the 8210-0014-Sl2.

The 8310 supports multiple sensor input types and includes terminals to connect up to eight analog and four digital sensors. Additionally, two separate 3-pin SDI-12 terminals are available, both connected internally to the same SDI-12 bus. Each input is assigned a unique number in the 8310 software. Data processing is also supported, including built-in options for several common equations, such as slope/offset correction. More complex or customized algorithms can be created using Basic programming. It is also possible to set alarms to trigger additional transmissions when measurements exceed a defined value. The alarm conditions can be based on the measurement value or measurement rate of change.

The 8310 can be programmed directly using the front-panel controls or a Personal Computer (PC). The front-panel controls include a small liquid crystal display and a set of arrow keys that allow the user to navigate the 8310's menu tree. Programming the 8310 using a PC is possible using a Universal Serial Bus (USB) or serial RS-232 connection. If a USB connection is used, a driver must be installed on the PC to create a virtual serial communications port. Serial communication with the 8310 requires a terminal program. When using a PC, it is possible to see the full set of menu options on a single screen, which simplifies the programming process. Using terminal software, it is also possible to back up the 8310's setup to a PC. Although the method of communication is similar to the 8210, the menu tree used to program the 8310 is substantially different. Anecdotal reports from some experienced users of the 8210 indicated that the 8310 is more challenging to program than the previous model.

Data are saved internally to a log file. The default format of the data log file (fig. 2) is a single row for each individual data measurement. This is different from the more common tabular format that places all the data from a single data scan in one row. It is possible to change the log file format using the settings in the menu tree, but the process may be too complex for some users. Additionally, if a sensor has multiple measurements, the order of the measurements in the log file may change from measurement to measurement, making data analysis more challenging. The 8310 has automatic backup

[1]Manufactured by Sutron Corp, Sterling, Va.

Figure 1. Photograph of Sutron 8310-N-S data logger and Geostationary Operational Environmental Satellite radio transmitter.

Table 1. Manufacturer's specifications for the Sutron 8310-N-S Data Collection Platform.

[°C, degrees Celsius; LCD, liquid crystal display; V, Volts; %, percent; mA, milliAmperes]

Feature	Specification
Housing dimensions	14 inches in length x 12 inches in width x 7.5 inches in height
Housing material	Molded fiberglass polyester
Weight	11 pounds
Operating temperature range	−40 to +60 °C (LCD operates to −20 °C)
Analog inputs	8
Analog input range	−0.1 to 5V with respect to ground
Analog input accuracy	0.002% of 5V
Digital inputs	6 (2 bidirectional)
Digital input range	0–5V
Digital outputs	2 (bidirectional)
Switched voltages	2 : Battery; 12V
Telemetry options	Satlink2, Sutron Data & Voice Modem, Radio, Direct Connect, GPRS, IRIDIUM, MODBUS, and custom devices using BASIC
Communication interfaces	1 RS-232/USB slave for user setup, 2 RS-232 for communications, 1 RS-232 for serial sensor or other, RS-485, and Ethernet
SDI-12 support	Version 1.3 compliant; 2 sets of SDI-12 wiring terminals
Power consumption	Typically 3 mA standby; 40 mA active

	A	B	C	D	E	
1	Station Name					
2	8310 Eval					
3	4/14/2014	15:15:00	TipBkt	0	in	G
4	4/14/2014	15:15:00	WindSpeed	1	mph	G
5	4/14/2014	15:15:00	Wind Dir	179.4		G
6	4/14/2014	15:15:00	IntTemp	24.51	C	G
7	4/14/2014	15:15:00	BaroPress	1011.14	mb	G
8	4/14/2014	15:30:00	TipBkt	0	in	G
9	4/14/2014	15:30:00	IntTemp	24.96	C	G
10	4/14/2014	15:30:00	Wind Dir	202.6		G
11	4/14/2014	15:30:00	WindSpeed	1.4	mph	G
12	4/14/2014	15:30:00	BaroPress	1011.2	mb	G
13	4/14/2014	15:45:00	TipBkt	0	in	G
14	4/14/2014	15:45:00	IntTemp	25.28	C	G
15	4/14/2014	15:45:00	WindSpeed	1.8	mph	G
16	4/14/2014	15:45:00	Wind Dir	199.6		G
17	4/14/2014	15:45:00	BaroPress	1011.24	mb	G
18	4/14/2014	16:00:00	TipBkt	0	in	G
19	4/14/2014	16:00:00	IntTemp	25.5	C	G
20	4/14/2014	16:00:00	Wind Dir	200		G
21	4/14/2014	16:00:00	WindSpeed	1.9	mph	G
22	4/14/2014	16:00:00	BaroPress	1011.42	mb	G
23	4/14/2014	16:15:00	TipBkt	0	in	G
24	4/14/2014	16:15:00	IntTemp	25.67	C	G
25	4/14/2014	16:15:00	WindSpeed	1.9	mph	G
26	4/14/2014	16:15:00	Wind Dir	204.9		G
27	4/14/2014	16:15:00	BaroPress	1011.34	mb	G
28	4/14/2014	16:30:00	TipBkt	0	in	G
29	4/14/2014	16:30:00	IntTemp	25.84	C	G
30	4/14/2014	16:30:00	Wind Dir	205.8		G
31	4/14/2014	16:30:00	WindSpeed	1.6	mph	G

Figure 2. Screen capture of Sutron 8310-N-S (serial number 1206109) log file default format. Data were collected from the following sensors: RM Young SDI-WS-RMY-2 wind sensor, FTS DigiBP SDI-12 pressure sensor, and Hydrological Services TB3 rain gage.

to an external Secure Digital (SD) card. When an SD card is inserted in the card slot on the face of the 8310, the LED display provides a 10-second countdown during which the user may cancel the automatic backup. At the end of the countdown, the data since the last backup will be recorded onto the SD memory card in a directory named “8310”. Each automatic backup creates a new file on the SD card with the date of the backup appended to the file name. Log files can also be manually saved to a SD card or PC using terminal software.

Methods

Three Sutron 8310 DCPs with firmware version 2.7.3 were evaluated with multiple sensors under varying temperatures and environmental conditions. Testing consisted of three phases. First, basic functionality and accuracy were evaluated on a test bench. Next, two of the 8310s were evaluated in an environmental test chamber (ESPEC[2] ESZ-3CA, serial number 017947). Finally, the third 8310 was deployed outdoors at the HIF for an extended period of time to evaluate its performance in an actual field environment.

Bench testing was performed on serial numbers 1208283 and 1208284. Testing was conducted at room temperature and included evaluation of: (1) analog input accuracy, (2) digital counter accuracy, (3) 4–20 mA accuracy (4) fixed and switched voltage accuracy, (5) power consumption, and (6) SDI-12 compliance tests. All voltage and current measurements were measured with a National Institute of Standards and Technology (NIST)-traceable, calibrated multimeter.[3] To check analog input accuracy, a calibrated digital power supply[4] was used to supply direct current (DC) voltages of 0 volts (V), 2.5 V, and 5 V to each of the 8310’s eight analog input terminals. The input value was compared to the 8310’s reported measured voltage and evaluated against the manufacturer’s specification for analog input accuracy. Digital inputs (or digital counter accuracy) were evaluated by connecting a simple push-button switch to each of the four digital input terminals. With the 8310’s digital inputs set up as counters, the switch was pressed and released 10 times, with approximately 1 second between presses. The measured count of each digital input was checked to verify that it recorded the correct number of counts. The 4–20 mA inputs were tested by applying constant current inputs of 4mA and 20mA to the first two analog input terminals. The current was measured by a calibrated multimeter and compared to the current value reported by the 8310.

For the fixed and switch voltage accuracy test, each of the 8310’s fixed and switched voltages were measured using a NIST-traceable, calibrated multimeter. Switched voltage outputs were enabled and disabled in the 8310’s software using a PC with a terminal interface. Each switched voltage was measured in both states. Power consumption can be computed from the voltage and current of the device. Because the input power voltage used in this evaluation was fixed, power consumption was calculated using only current measurements. All power consumption data were measured by placing a multimeter in series with the 8310 power input to measure current. Instantaneous current measurements were recorded during two consecutive 8310 data measurements. The steady-state current draw in standby mode was also recorded. Compliance with SDI-12 Standard Version 1.3 (SDI-12 Support Group, January 2013) was evaluated using a PC and a first generation SDI-12 verifier using version 2.21 of the verifier software (NR Systems Inc., 1999) in data logger test mode. The SDI-12 verifier data logger test is an automated procedure that simulates a SDI-12 sensor interacting with the logger. As SDI-12 communication is taking place, the verifier monitors the data and electrical characteristics to verify that they comply with the requirements described in the SDI-12 standard.

[2]ESPEC North America, Inc., Hudsonville, Mich.

[3]HP 34401A multimeter, Hewlett-Packard Co., Palo Alto, Calif.

[4]Tektronix PS280 DC power supply, Tektronix, Inc., Beaverton, Oreg.

Two 8310s (serial numbers 1208283 and 1208284) were evaluated in an environmental test chamber. The environmental test chamber is capable of achieving and accurately maintaining temperatures from −40 to 60 °C and is capable of achieving ±0.3 °C accuracy. The temperature chamber is biennially calibrated and verified using NIST-traceable standards. Operation of the environmental chamber was automated using custom software (LabVIEW).[5] Temperature testing was performed to evaluate the ability of the 8310 to log data over its full specified temperature range. The chamber temperature was cycled between −40 and 60 °C, completing three temperature cycles over the course of the test (fig. 3). The cycles consisted of "ramp" periods during which the chamber was transitioning between temperatures, and "soak" periods in which the temperature was held at a constant value to allow the device under test to equilibrate to the new temperature. During ramp periods, the rate of temperature change was 1 °C per minute. Soak periods at intermediate temperatures were 120 minutes. Soak times at maximum and minimum temperatures were 240 minutes. The initial planned test was estimated to take 70 hours, but the actual test lasted approximately 77 hours due to longer than expected ramp times at cold temperatures.

Table 2 lists the sensors that were logged during temperature chamber testing. All SDI-12 sensors were connected to the data logger through a custom SDI-12 bus box. A digital push-button switch was used to simulate a tipping bucket rain gage. The switch was used to simulate several tips at the beginning of testing, but this function was not tested at high or cold extreme temperatures. The 8310 was placed inside the environmental chamber and configured to log data from each sensor at 5-minute intervals. The data were transmitted at 10-minute intervals at a rate of 300 baud. Because the data were transmitted to a local radio frequency (RF) receiver, a dummy load was connected to the 8310's antenna output. The dummy load was placed outside the environmental chamber and attached to the 8310 with an RF cable that was routed through a chamber port. The transmitted RF signal was received by a Microcom[6] GOES transmitter test set TS-101-GOES and the data were recorded on an attached laptop. Transmissions were monitored for data accuracy and transmission characteristics, such as time drift, signal strength, and frequency drift, and were compared to standards from the National Oceanic and Atmospheric Administration's National Environmental Satellite, Data, and Information Service (NESDIS; National Oceanic and Atmospheric Administration/National Environmental Satellite, Data, and Information Service, 2009).

Outdoor deployment testing was performed at a site next to the HIF building at Stennis Space Center, Mississippi, over 7 weeks, from April 14 to June 5, 2014, to evaluate the 8310 in a real-world environment. The complete outdoor setup consisted of the 8310 (serial number 1206109), three attached sensors, solar panel, solar regulator, and antenna (fig. 4). Table 3 lists the equipment used. The 8310, battery, and solar regulator were installed in an enclosed housing and mounted on a wooden fence (fig. 4). The 8310 was programmed to log data at 15-minute intervals and to transmit the data hourly to GOES satellites. The data sent to GOES were verified by monitoring the USGS Emergency Data Distribution Network Web site (http://eddn.usgs.gov/). The 8310 was programmed to include redundant datasets, meaning that each transmission includes the current measurement and the previous measurement.

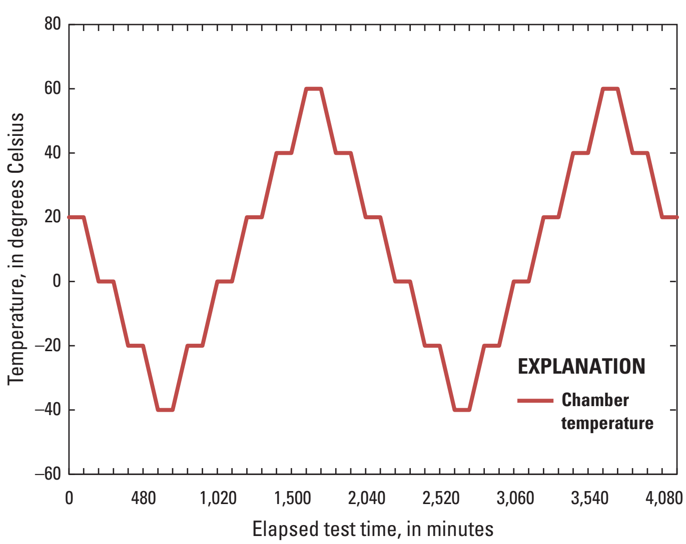

Figure 3. Graph showing emperature profile used during temperature cycling testing for Sutron 8310-N-S (serial numbers 1208283 and 1208284). Temperatures were applied during logging (5-minute intervals) and transmissions (10-minute intervals).

Table 2. Instruments used during temperature chamber testing of Sutron 8310-N-S.

Instrument	Type	Serial Number
Handar model 436 shaft encoder	Single parameter SDI-12	0625
Paroscientific PS2 water stage sensor	Single parameter SDI-12	49239
Hydrolab Datasonde 4	Multiparameter SDI-12 (4)	35390
HP 6114A precision power supply	Analog	2110A-02381
Push-button switch, generic, lab stock	Digital Counter	None

[5]System design software by National Instruments Corp., Austin, Tex.

[6]Manufactured by Microcom Design, Inc., Cockeysville, Md.

Figure 4. Photograph of deployment site used for Sutron 8310-N-S field test.

Table 3. Instruments used during deployment testing of Sutron 8310-N-S at Stennis Space Center, Mississippi.

Instrument	Type	Serial number
RM Young SDI-WS-RMY-2 wind sensor	Multiparameter (2) SDI-12	055114
FTS DigiBP SDI-12 pressure sensor	Single Parameter SDI-12	055145
Hydrological Services TB3 rain gage	Tipping bucket rain gage	97–895

Results

The performance of the three 8310 DCPs was evaluated using the methods described above. Bench testing results are shown in table 4. Analog voltages were measured to be accurate to within ±0.001 V at the tested voltages of 0, 2.5, and 5 Volts Direct Current (VDC) for both units tested. Power consumption was measured with the Satlink disconnected from the logger. Standby power consumption on serial numbers 1208283 and 1208284 was measured at 0.003 amperes. During a measurement, the power consumption increased to 0.015 amperes. Both values meet the manufacturer's specification.

Of the two DCPs evaluated during temperature chamber testing, one unit (serial number 1208283) experienced data transmission errors at a rate of 3.22 percent. The data from the other unit (serial number 1208284) were accurately transmitted to the test set. The errors do not appear to be related to environmental temperature (fig. 5). The maximum frequency drift over the temperature range was +23.10 Hz, which occurred on serial number 1208284. This value is well within the NESDIS specification of ±125 Hz (National Environmental Satellite, Data, and Information Service, 2009). Time drift measurements fell within the manufacturer's specifications for both units tested.

The data from deployment testing of serial number 1206109 included several transmission failures. Over the course of 7 weeks, 1,250 data transmissions were expected. Of these, 6 were not received at all and 78 were corrupted. These 84 errors result in a total error rate of 6.72 percent. These

Table 4. Results of bench testing at room temperature of two Sutron 8310-N-S Data Collection Platforms (serial numbers 1208283 and 1208284) for compliance with selected manufacturer's specifications.

[V, Volts; %, percent; mA, milliAmperes]

Feature/specification	Test	Test Result			
		1208283		1208284	
Analog input accuracy	Voltage inputs at 0, 2.5, and 5 V	Error <0.0001 V		Error <0.0001 V	
Digital counter accuracy	Push-button switch, pressed 10 times	10 counts		10 counts	
4–20 mA input accuracy	Current measurement	Error <0.1%		Error <0.1%	
Power consumption	Standby	~3mA		~3mA	
	During SDI-12 measurement	~15 mA		~15 mA	
Fixed and switched voltage accuracy	+12V switched	On: 12.565 V	Off: 0.037 V	On: 12.645 V	Off: 0.063 V
	+5V switched	On: 5.023 V	Off: 0.033 V	On: 5.057 V	Off: 0.029 V
	+12V fixed	12.646 V		12.645 V	
	+5V fixed	5.026 V		5.061 V	
SDI-12 version 1.3 compliance	SDI-12 verifier, version 2.21	Pass		Pass	

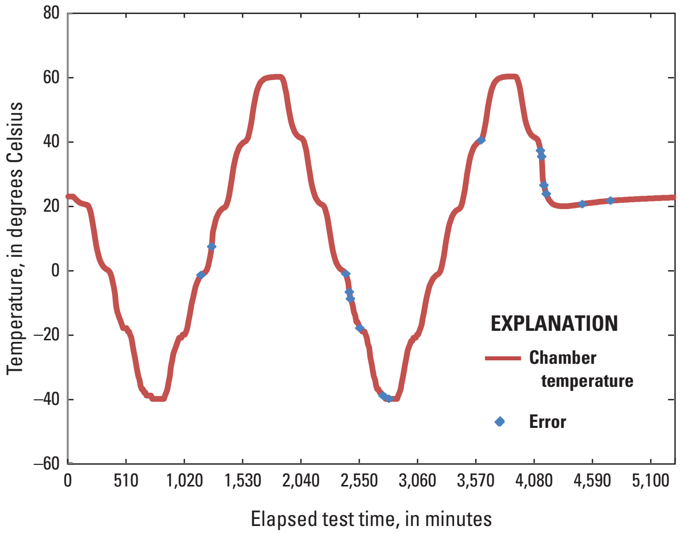

Figure 5. Graph showing Sutron 8310-N-S (serial number 1208283) transmission errors during temperature chamber test, including both missing transmissions and corrupted transmissions. Serial number 1208284 experienced no transmission errors during temperature chamber testing.

84 transmission errors included 16 back-to-back pairs. Even transmitting redundant datasets, these pairs resulted in missing data. The data were compared to historical weather records from Weather Underground (http://www.wunderground.com) to determine if the errors were correlated with weather patterns, but no correlation was found. During this period, air temperatures ranged from 39 to 87 degrees Fahrenheit, and no rainfall was recorded. The errors do not appear to be correlated with temperature, time of day, or battery voltage. Subsequent testing of a WaterLOG Storm 3 data logger with a WaterLOG H-2221[7] GOES transmitter at the same site with the same instruments, from July 2 to September 30, 2014, exhibited no transmission errors. A more specific cause of the errors is unknown. Future evaluations of DCPs should include multiple transmitting devices in the same environment to control for atmospheric conditions.

[7]Manufactured by WaterLOG, Yellow Springs, Ohio.

Summary

The Sutron 8310 was evaluated to determine if it met the manufacturer's stated specifications, and if it was suitable for use in USGS hydrologic data-collection activities. Three units were tested. The evaluations included bench testing, temperature chamber testing over the device's full operating temperature range, and deployment testing in an outdoor environment. The device met the manufacturer's stated specifications, but notable data transmission errors were encountered during testing, which could be a problem for users who rely on telemetered data. Overall, the 8310 is a powerful device with many features and may be a suitable choice to consider using for data collection and telemetry at USGS field locations.

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