TM

IoT System Performance Analysis

Objective

* Share research findings and learnings about system performance from several IoT systems on the Helium network

Agenda

* About Gary and Mike

* System overview

* Problem statement

* Performance Measurement

* Root Cause

* Solution options

* Current status

* Areas for Further investigation

* References

About Gary and Mike

* Hitechdb LLC is an IoT consulting company that designs and deploys IoT monitoring solutions using the Helium network

* Gary has been designing and installing commercial and high-end residential HVAC systems for 30 years, specializing in control integration, load calculation, foam envelopes, variable refrigerant flow and geothermal solutions.

* Mike is an electrical engineer turned software engineer turned project/program/product manager who has spent his career designing, building, and delivering systems and solutions in the Telecom, Mobile, and Healthcare industries.

Systems Overview

System Name	Site Description	Helium Console System	Location	System Build Date	System Deploy Date	Sensors	LoRa Gateway(s)
Longview	2500sf home with 2 cabin outbuildings on the property	Production	Starkville, MS	5/10/21	5/24/21	TBHV110_4 TBHH100_7 TBHH100_8 TBWL100_7 TBWL100_8 TBWL100_9 TBWL100_10	restless-champagne-orca
Rogers	2500sf home	VIP	Rogers, AR	8/5/21	8/17/21	TBHV110_5 TBHH100_5 TBWL100_5 TBWL100_6	dizzy-eggplant-corgi (primary) bald-pineapple-wren
Sunrise	2500sf home	VIP	Davis, CA	8/9/21	8/21/21	TBHV110_6 TBHH100_6	best-pearl-aardvark

Problem Statement

Longview

Consolidated View   Great Room   East Cabin   North Cabin   Workout Room Air Handler   Attic West Air Handler   Attic East Air Handler   Attic Dehumidifier

Great Room

Sensor ID: TBHV110_4	Temperature a few seconds ago	70 °F	Humidity a few seconds ago	47 %	Air Quality Status a few seconds ago	Lightly Polluted	Battery Voltage a few seconds ago	3.6 V

East Cabin

Sensor ID: TBHH100_8	Temperature 2 hours ago	70 °F	Humidity 2 hours ago	69 %	Battery Voltage 2 hours ago	3.6 V

North Cabin

Sensor ID: TBHH100_7	Temperature a few seconds ago	73 °F	Humidity a few seconds ago	78 %	Battery Voltage a few seconds ago	3.6 V

Workout Room Air Handler

Sensor ID: TBWL100_10	Temperature 4 hours ago	66 °F	Humidity 4 hours ago	68 %	Water Leak 4 hours ago	No Leak Detected ●	Battery Voltage 4 hours ago	3.6 V

Attic West Air Handler

Sensor ID: TBWL100_7	Temperature 9 hours ago	72 °F	Humidity 9 hours ago	57 %	Water Leak 9 hours ago	No Leak Detected ●	Battery Voltage 9 hours ago	3.6 V

Attic East Air Handler

Sensor ID: TBWL100_9	Temperature 6 hours ago	68 °F	Humidity 6 hours ago	65 %	Water Leak 6 hours ago	No Leak Detected ●	Battery Voltage 6 hours ago	3.7 V

Attic Dehumidifier

| Sensor ID: TBWL100_8	Temperature 2 hours ago	70 °F	Humidity 2 hours ago	60 %	Water Leak 2 hours ago	No Leak Detected ●	Battery Voltage 2 hours ago	3.6 V

Problem Statement

* Hitechdb, a Helium partner, has 3 systems on the Helium network, consisting of various Browan sensors.

* All 3 systems exhibited similar behavior

  * Performance, as defined by Packet Completion Percentage, declined from near 100% to 20-30% within 18 – 23 days of system deployment.
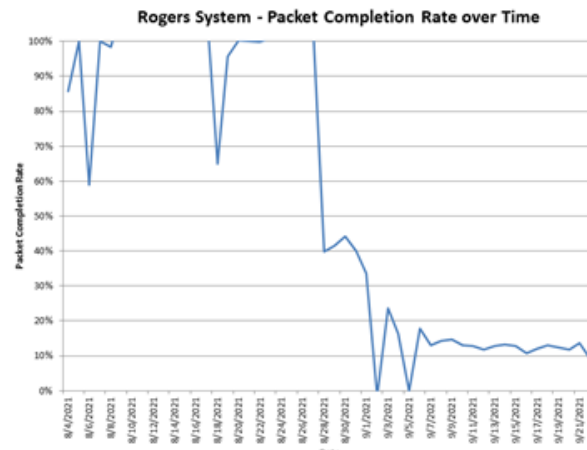
System Performance

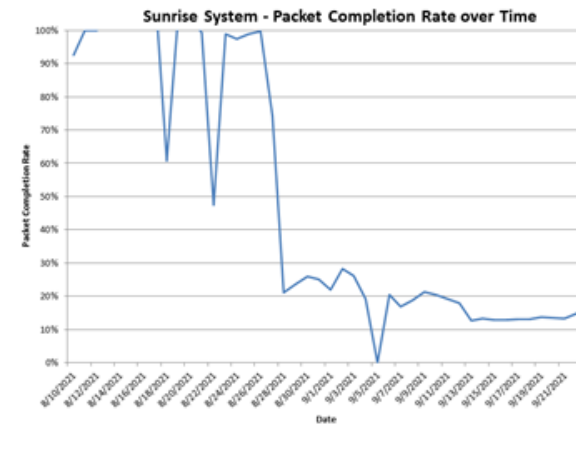| Hitechdb Systems Performance Summary		
System Name	**Initial Daily PC%**	**Steady State Daily PC%**
Longview	~100%	~14%
Rogers	~100%	~13%
Sunrise	~100%	~14%

Table 2 – Systems Performance Summary

Longview System Performance
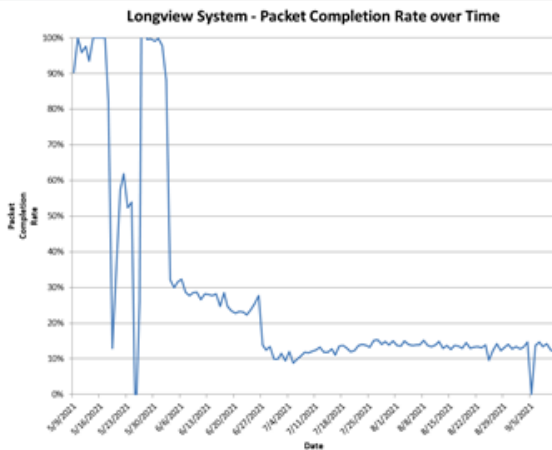
Rogers System Performance

Sunrise System Performance

Performance Measurement – Packet Completion Rate

	A	BF	BG	BH	BI	BJ	BK	BL	BM	BN	BO	BP	BQ	BR	BS	BT	BU	BV	BW
1	Date	Frame Up (TBWL100_6)	Frame Down	Packets Xferred	DC Used	Frame Up Yest (Calc)	Frame Down Yest (Calc)	Packets Xferred Yest (Calc)	PC% (Calc) (BL/BJ)	DC UsedY est (Calc)	Frame Up (TBHV110_5)	Frame Down	Packets Xferred	DC Used	Frame Up Yest (Calc)	Frame Down Yest (Calc)	Packets Xferred Yest (Calc)	PC% (Calc) (BU/BS)	DC UsedY est (Calc)
67	10/6/2021	1465	103	737	737	30	0	3	10%	3	10047	1268	7585	7585	298	37	37	12%	37
68	10/7/2021	1492	103	740	740	27	0	3	11%	3	10342	1305	7622	7622	295	37	37	13%	37
69	10/8/2021	1499	103	742	742	7	0	2	29%	2	10630	1358	7742	7742	288	53	120	42%	120
70	10/9/2021	1539	103	746	746	40	0	4	10%	4	10933	1358	7781	7781	303	0	39	13%	39
71	10/10/2021	1563	103	750	750	24	0	4	17%	4	11231	1358	7818	7818	298	0	37	12%	37
72	10/11/2021	1581	103	751	751	18	0	1	6%	1	11487	1358	7850	7850	256	0	32	13%	32
73	10/12/2021	1603	103	754	754	22	0	3	14%	3	11789	1358	7889	7889	302	0	39	13%	39
74	10/13/2021	1627	103	758	758	24	0	4	17%	4	12075	1358	7924	7924	286	0	35	12%	35
75	10/14/2021	1657	103	761	761	30	0	3	10%	3	12358	1358	7959	7959	283	0	35	12%	35
76	10/15/2021	1684	103	764	764	27	0	3	11%	3	12639	1358	7994	7994	281	0	35	12%	35
77	10/16/2021	1717	103	768	768	33	0	4	12%	4	12981	1358	8037	8037	342	0	43	13%	43
78	10/17/2021	1731	103	770	770	14	0	2	14%	2	13254	1358	8071	8071	273	0	34	12%	34
79	10/18/2021	1755	103	774	774	24	0	4	17%	4	13493	1358	8101	8101	239	0	30	13%	30
80	10/19/2021	1785	103	777	777	30	0	3	10%	3	13791	1358	8137	8137	298	0	36	12%	36
81	10/20/2021	1812	103	780	780	27	0	3	11%	3	14069	1358	8172	8172	278	0	35	13%	35
82	10/21/2021	1837	103	783	783	25	0	3	12%	3	14367	1358	8209	8209	298	0	37	12%	37
83	10/22/2021	1859	103	786	786	22	0	3	14%	3	14645	1358	8244	8244	278	0	35	13%	35
84	10/23/2021	1883	103	790	790	24	0	4	17%	4	15007	1358	8289	8289	362	0	45	12%	45
85	10/24/2021	1913	103	793	793	30	0	3	10%	3	15245	1358	8320	8320	238	0	31	13%	31
86	10/25/2021	1923	103	794	794	10	0	1	10%	1	15501	1358	8352	8352	256	0	32	13%	32
87	10/26/2021	1947	103	798	798	24	0	4	17%	4	15814	1358	8390	8390	313	0	38	12%	38

Root Cause

* When looking at RSSI, SNR, and Spreading Factor (SF) data from the sensor logs, a strong correlation is seen between the SF value and the packet completion rate. Specifically, the following two observations apply to every sensor in the Rogers and Sunrise systems:

* When the sensor is activated, the SF starts at 7 then over time increments to 10

* Shortly after achieving a spreading factor of 10, the packet completion rate drops dramatically

* **When the sensor's spreading factor changes to SF10, packet completion rate declines significantly**

Root Cause

Sensor TBHH100_6: RSSI, SNR, and Spreading Factor Over Time

Sunrise System - Sensor TBHH100_6 - Packet Completion Rate over Time

12/1/2021
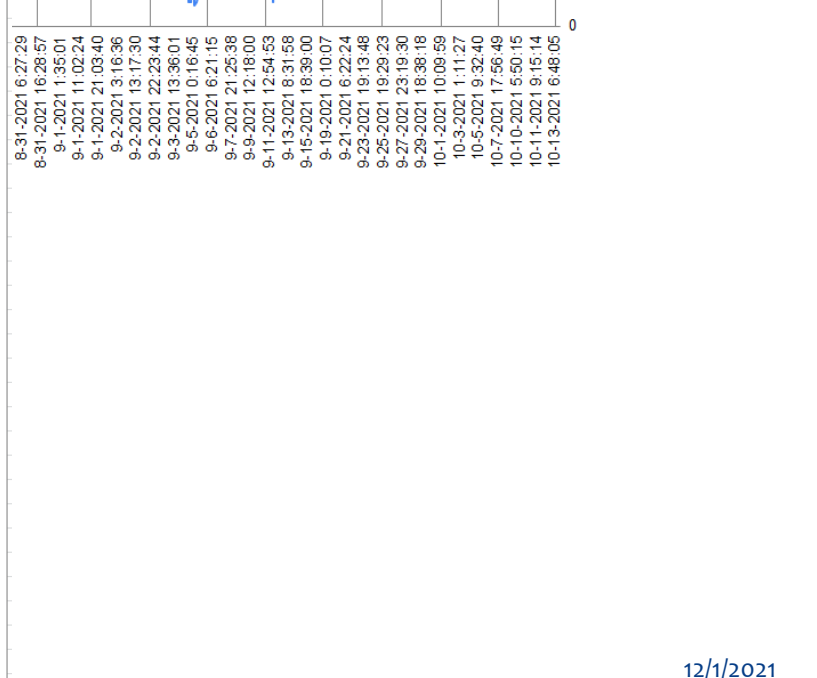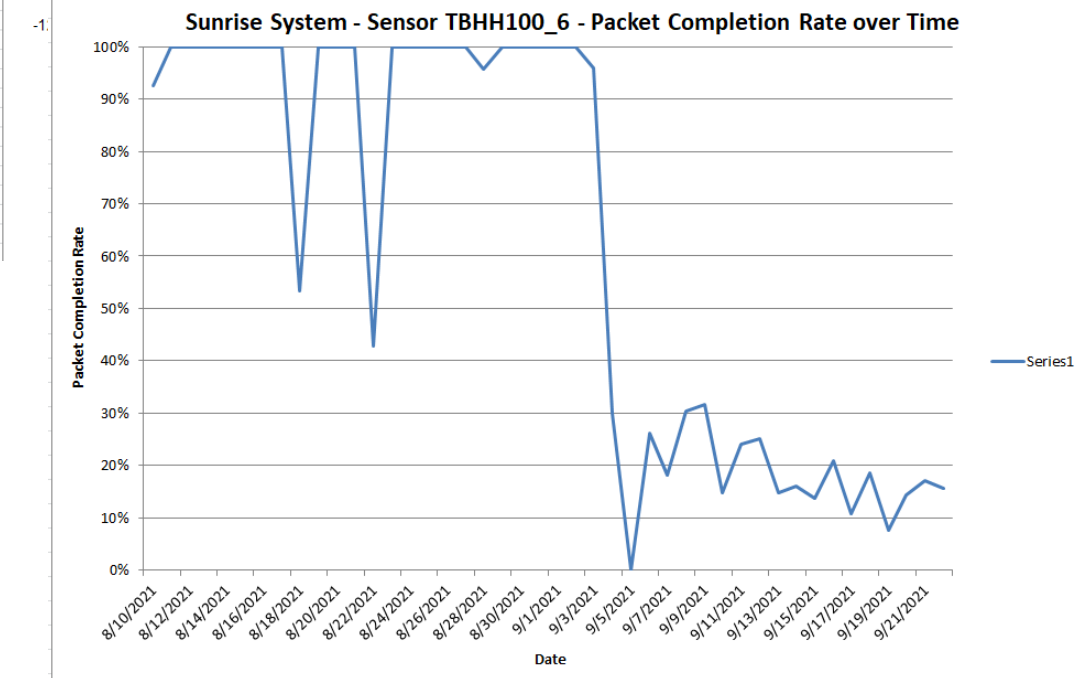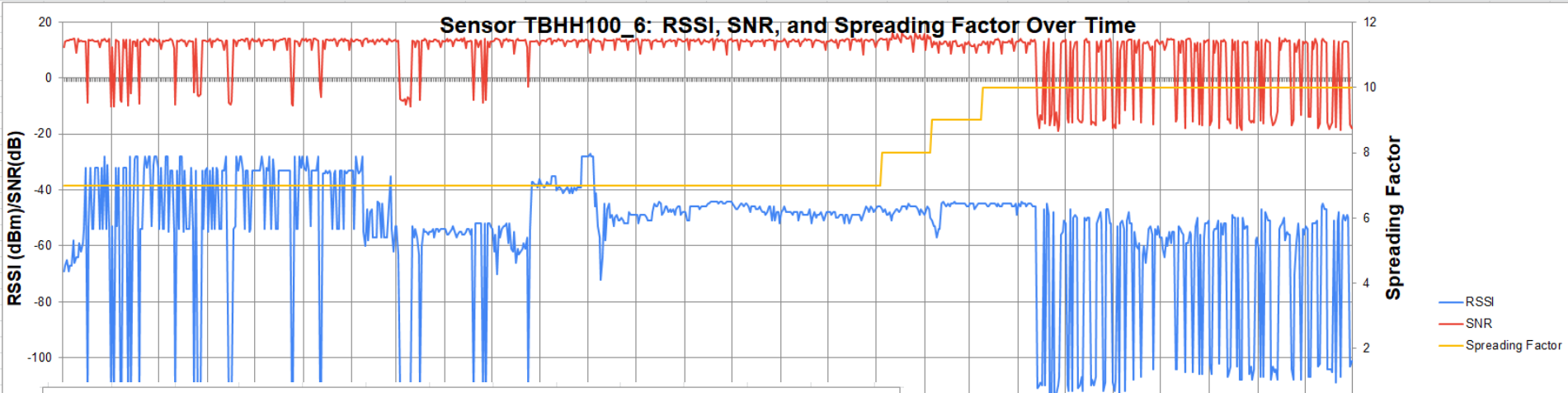
Solution Options

* Q: How do you get the sensor to change from SF10 to a lower SF?
* A:
  * ~~Send a UART command to the sensor from the PC~~
  * ~~Send a downlink on port 0 to set SF7~~
  * enable ADR

Enabling ADR

Enabling ADR - Results

	Date	Frame Up TBHV110_4	Frame up Yest. (CALC)	Frame Down	Packets Transferred	Packets Transferred Yest. (CALC)	PC% (CALC)	DC Used	DC Used Yest. (CALC)
476	11/9/2021	48564	270	505	10305	32	12%	10305	32
477	11/10/2021	48862	298	505	10336	31	10%	10336	31
478	11/11/2021	49194	332	505	10375	39	12%	10375	39
479	11/12/2021	49460	266	505	10405	30	11%	10405	30
480	11/13/2021	49770	310	505	10444	39	13%	10444	39
481	11/14/2021	50026	256	505	10476	32	13%	10476	32
482	11/15/2021	50292	266	505	10509	33	12%	10509	33
483	11/16/2021	50410	118	505	10521	12	10%	10521	12
484	11/17/2021	50782	372	505	10522	1	0%	10522	1
485	11/18/2021	51148	366	505	10560	38	10%	10560	38
486	11/19/2021	51434	286	505	10595	35	12%	10595	35
487	11/20/2021	51574	140	525	10635	40	29%	10635	40
488	11/21/2021	52062	488	556	10668	33	7%	10668	33
489	11/22/2021	52300	238	570	10699	31	13%	10699	31
490	11/23/2021	52586	286	588	10732	33	12%	10732	33
491	11/24/2021	52876	290	621	10769	37	13%	10769	37
492	11/25/2021	53166	290	734	10979	210	72%	10979	210
493	11/26/2021	53459	293	933	11267	288	98%	11267	288
494	11/27/2021	53775	316	1183	11580	313	99%	11580	313
495	11/28/2021	54061	286	1269	11858	278	97%	11858	278
496	11/29/2021	54319	258	1333	12098	240	93%	12098	240
497	11/30/2021	54606	287	1555	12384	286	100%	12384	286
498	12/1/2021	54889	283	1774	12666	282	100%	12666	282

Enabling ADR, but….

* Q: For sensors already deployed, how long does it take for the SF to update – and will it stay off SF10?

	A	B	C	D	E	F	G	H	I	J	K
1	Sensor ID	System	Enable ADR Time	fcount at Enable ADR	Chg to SF7 Time	fcount at Change to SF7	Delta Time (HH:MM)	Delta fcount	Xmit Rate (Msg/Day)	Days to Switch (G/24)	Days to Switch (H/I)
2	TBWL100_5	Rogers	11-20-2021 12:09:47	2884	11-27-2021 19:07:01	3063	174:57	179	24	7	7.5
3	TBWL100_6	Rogers	11-20-2021 12:09:47	2607	11-28-2021 14:23:14	2820	194:13	213	24	8	8.9
4	TBHH100_5	Rogers	11-20-2021 12:09:47	2665	11-24-2021 2:09:14	2750	85:59	85	24	3	3.5
5	TBHV110_5	Rogers	11-20-2021 12:09:47	23093	11-21-2021 0:49:59	23245	12:40	152	288	0	0.5
6	TBSL100_2	Livingston	11-20-2021 9:01:45	13402	11-20-2021 14:46:55	13471	5:45	69	288	0	0.2
7	TBHV110_4	Longview	11-19-2021 6:30:00	51459	11-24-2021 11:59:41	52959	125:29	1500	288	5	5.2
8	TBHH100_8	Longview	11-19-2021 6:30:00	5454			##############	-5454	24		
9	TBHH100_7	Longview	11-19-2021 6:30:00	4714	11-30-2021 10:28:24	4979	267:58	265	24	11	11.0
10	TBWL100_7	Longview	11-19-2021 6:30:00	4693			##############	-4693	24		
11	TBWL100_8	Longview	11-19-2021 6:30:00	4639	11-26-2021 12:42:03	4813	174:12	174	24	7	7.3
12	TBWL100_9	Longview	11-19-2021 6:30:00	4616			##############	-4616	24		
13	TBWL100_10	Longview	11-19-2021 6:30:00	4658			##############	-4658	24		
14	TBHH100	Mercy	11-29-2021 6:52:00	60434	11-29-2021 21:42:38	60600	14:50	166	207	0	0.8

Future Investigation &

* Once the ADR takes effect, will the sensor stay off SF10?
* What about a different sensor type?

	Date	Frame Up (LHT65_2)	Frame Down	Packets Xferred	DC Used	Frame Up Yest (Calc)	Frame Down Yest (Calc)	Packets Xferred Yest (Calc)	PC% (Calc)	DC UsedYest (Calc)
1										
97	11/5/2021	3536	229	2279	2279	148	0	148	100%	148
98	11/6/2021	3622	229	2365	2365	86	0	86	100%	86
99	11/7/2021	3692	229	2435	2435	70	0	70	100%	70
100	11/8/2021	3757	229	2500	2500	65	0	65	100%	65
101	11/9/2021	3827	229	2570	2570	70	0	70	100%	70
102	11/10/2021	3900	229	2643	2643	73	0	73	100%	73
103	11/11/2021	3981	229	2724	2724	81	0	81	100%	81
104	11/12/2021	4051	229	2794	2794	70	0	70	100%	70
105	11/13/2021	4126	229	2869	2869	75	0	75	100%	75
106	11/14/2021	4190	229	2933	2933	64	0	64	100%	64
107	11/15/2021	4258	229	3001	3001	68	0	68	100%	68
108	11/16/2021	4304	229	3047	3047	46	0	46	100%	46
109	11/17/2021	4393	229	3062	3062	89	0	15	17%	15
110	11/18/2021	4472	229	3116	3116	79	0	54	68%	54
111	11/19/2021	4545	229	3189	3189	73	0	73	100%	73
112	11/20/2021	4625	229	3269	3269	80	0	80	100%	80
113	11/21/2021	4700	229	3344	3344	75	0	75	100%	75
114	11/22/2021	4760	229	3404	3404	60	0	60	100%	60
115	11/23/2021	4833	229	3477	3477	73	0	73	100%	73
116	11/24/2021	4904	229	3548	3548	71	0	71	100%	71
117	11/25/2021	4977	229	3620	3620	73	0	72	99%	72
118	11/26/2021	5050	229	3693	3693	73	0	73	100%	73
119	11/27/2021	5129	229	3772	3772	79	0	79	100%	79
120	11/28/2021	5201	229	3844	3844	72	0	72	100%	72
121	11/29/2021	5265	229	3908	3908	64	0	64	100%	64
122	11/30/2021	5340	229	3983	3983	75	0	75	100%	75
123	12/1/2021	5408	229	4051	4051	68	0	68	100%	68

References

* Full report and data files are available here
* https://github.com/mikedsp/helium/tree/master/Browan%20Sensor%20Performance%20Analysis%20on%20the%20Helium%20Network

Thank You!

* Gary Thatcher: garyt@hitecdb.com
* Mike Boucher: mikeb@hitechdb.com

Bonus Slides

Sensor List

Sensor ID	Function	Packet Triggers
TBHV110_4	Indoor Air Quality	Packet Triggers: **5-minute inactivity**, ±2°C delta(environment temp), ±5 %RH Delta, ±25 IAQ Index Delta.
TBHH100_7	Temp/Humidity	**60-minute inactivity**, ±2 °C delta, ±5 %RH Delta
TBHH100_8	Temp/Humidity	**60-minute inactivity**, ±2 °C delta, ±5 %RH Delta
TBWL100_7	Leak Detect, Temp/Humidity	**60-minute inactivity**, ±2 °C delta, ±5 %RH Delta, water leakage detection per 5 minutes
TBWL100_8	Leak Detect, Temp/Humidity	**60-minute inactivity**, ±2 °C delta, ±5 %RH Delta, water leakage detection per 5 minutes
TBWL100_9	Leak Detect, Temp/Humidity	**60-minute inactivity**, ±2 °C delta, ±5 %RH Delta, water leakage detection per 5 minutes
TBWL100_10	Leak Detect, Temp/Humidity	**60-minute inactivity**, ±2 °C delta, ±5 %RH Delta, water leakage detection per 5 minutes