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		Revision:	B

Product: Data Point

Description: Long Range Wireless Sensor



Revision History

Revision	Date	Reason	Edited By
A	16/03/23	Created	Lee Fleck
B	29/09/23	Push button ergonomics simplified	Lee Fleck

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1. Introduction

The DP (Data Point) is a temperature and humidity wireless sensor packaged for industrial use. The DP has a custom injection molded case and comes with a wall mounting bracket. It is sealed to IP66 for use in aggressive environments from -40°C to +65°C.

The DP has been ergonomically designed so that an unskilled person can install, use and maintain the device without resort to specialist equipment.

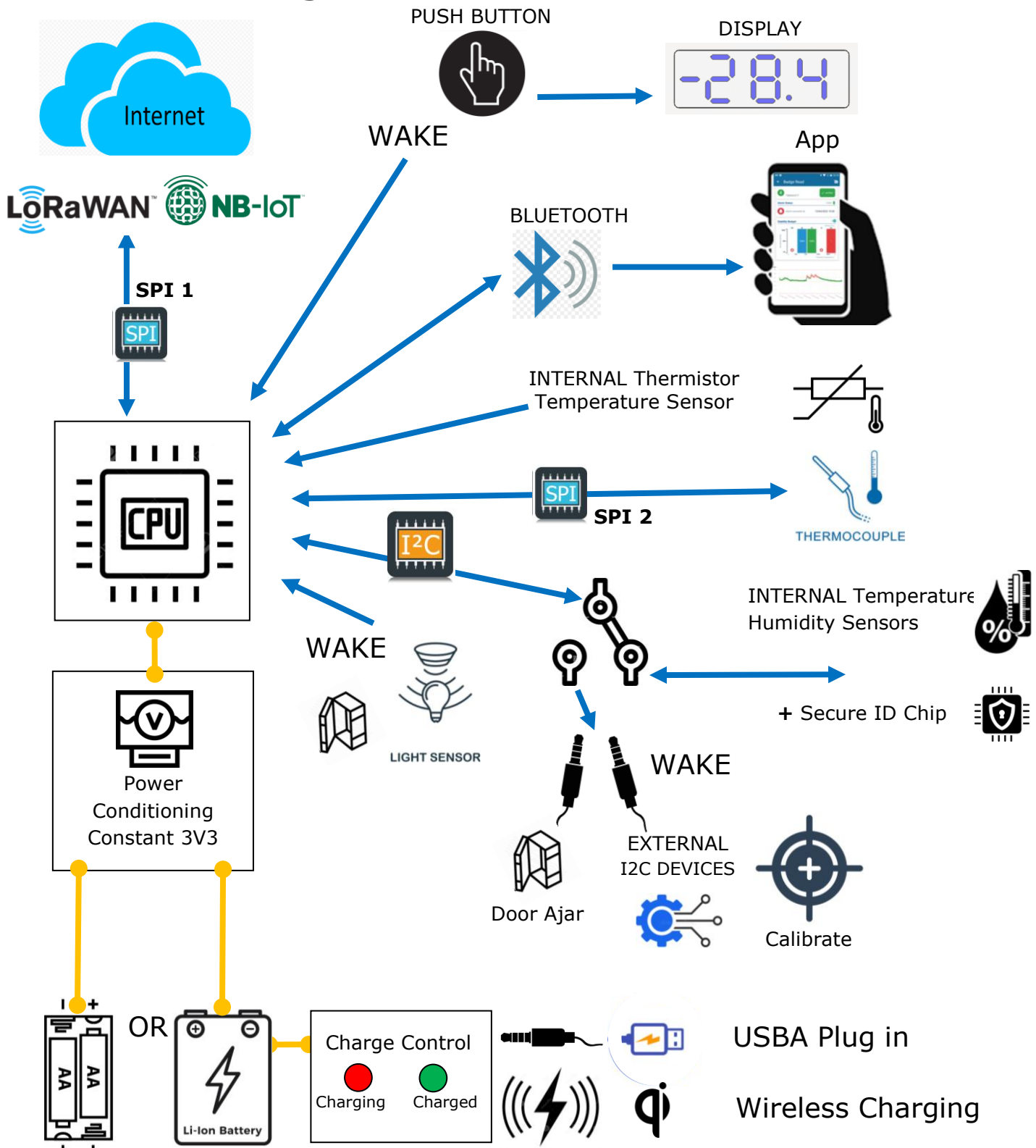
Features

- Three digit LED display [readable at all temperatures and light levels]
- Push Button to check in and read temperature
- Bluetooth Low Energy communications to a smart phone App.
- Data Logging with measurements recorded and stored at periodic intervals
- LoRaWAN or NB-IOT roaming communications to flush data to public or private internet gateways.
- Optic sensor to monitor door and package openings.
- Powered by 2 x AA standard batteries
(can be disposed of in general waste).

Plug in Accessories

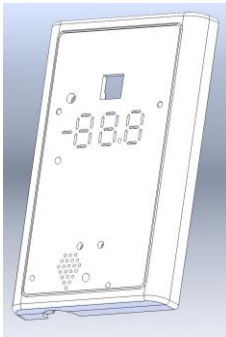
- External Temperature and Humidity Sensor
- External Type K or T Thermocouple probe for immersion and an extended temperature range. (-273°C to +999°C).
- Door Ajar magnetic reed switch.
(Where wired door switches are required).
- LiPOL rechargeable battery.
- External high gain antenna (standard RPSMA socket)
- Calibration dongle. (Availability TBA)
- Alarm Beacon. (Availability TBA)
- Infra Red Temperature probe (Availability TBA)

2. Block Diagram

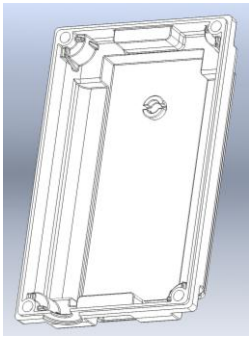


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3. Enclosure



FRONT



REAR



BRACKET



Sealing plug for jack

The custom injection mold cases are manufactured in Medical Grade ABS plastic (with anti bacterial additive). Specifically, in MAGNUM ABS 8391 (complies with U.S.FDA FCN 1525) and in colour - RAL7035 - Light Grey.

The front of the DP is sealed with a membrane keypad which integrates the push button.

The 3.5mm jack is sealed with a removable rubber bung.

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5. Sensors

1) Internal Thermistor Sensor

This is fitted as standard on all DPs. As the bulk of the market is temperature monitoring only, this meets the basic requirement at minimum cost. This sensor is pre calibrated with a 128 point LUT (look up table) giving it an out of box reproducible accuracy of +/- 0.3°C from -30°C to +50°C.

2) Internal Temperature and Humidity Sensor

This is fitted when Humidity monitoring is a requirement.

This is a SHT4x 4th Generation, High-Accuracy, Ultra-Low-Power, 16-bit Relative Humidity and Temperature Sensor from Sensirion.

<https://www.sensirion.com/products/catalog/SHT40>

This comes in three variants of increasing accuracy:

SHT40	+/- 0.2°C	+/-1.8% RH	1,000 up price €1.25 [mouser.com]
SHT41	+/- 0.2°C	+/-1.8% RH	1,000 up price €1.75 [mouser.com]
SHT45	+/- 0.1°C	+/-1.5% RH	1,000 up price €3.25 [mouser.com]

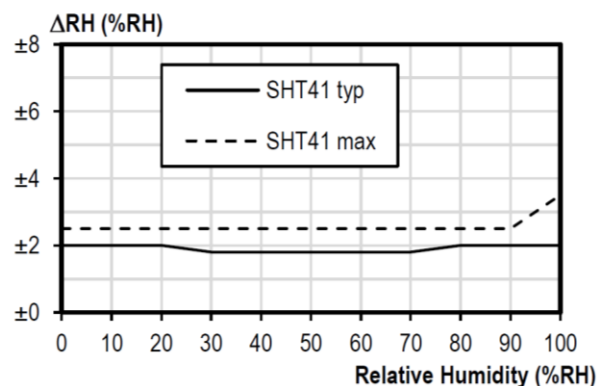
A protective filter cap clips over these sensors on the internal PCB.

SF2 1,000 up price €1.00

As Humidity sensing requires direct air exposure to the environment, this is provisioned with a 10mm circular hole punched into the front membrane keypad.



FRONT




The IP rating of the device is now reduced to IP55.

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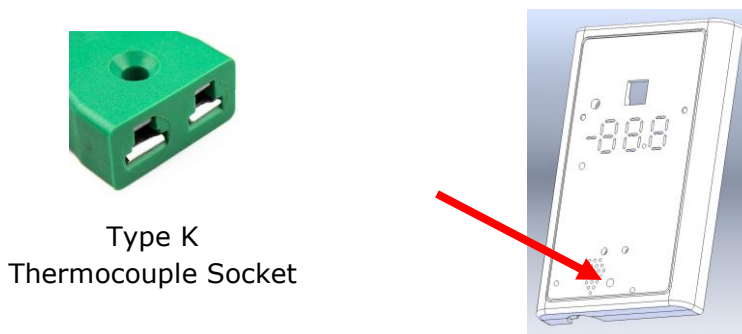
3) External Sensors

For applications where the DP is mounted outside the monitoring volume, then external flying lead sensors are available. Wall mounted DPs allow local users to directly read the sensor values on the display and generally have improved wireless connectivity.

Option (i) A Sensirion SHT4x temperature and humidity sensor (as above)  plugged into the DP jack.

Option (ii) A Type K [Food] or T [Cryogenics] Thermocouple Probe.

Physical connection of the external probe is provisioned with a thermocouple socket mounted over the membrane keypad on the lower front face:



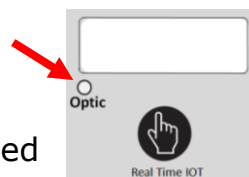
These options do not reduce the IP66 rating of the device.

3) Optic Sensor

This is fitted as standard on all DPs. A window at the bottom left of the display is used for light detection.

When the is sensor enabled, the DP records light ON / light OFF events. This can be used as an alternative door ajar monitor or for box opened events for goods in transit applications.

In many cases, this obviates the need to fit a wired connection to a door switch. The light detection threshold is settable in hardware with a default value of 25 LUX. When a light event occurs, the DP display will momentarily shown OPEN or CLOSED.



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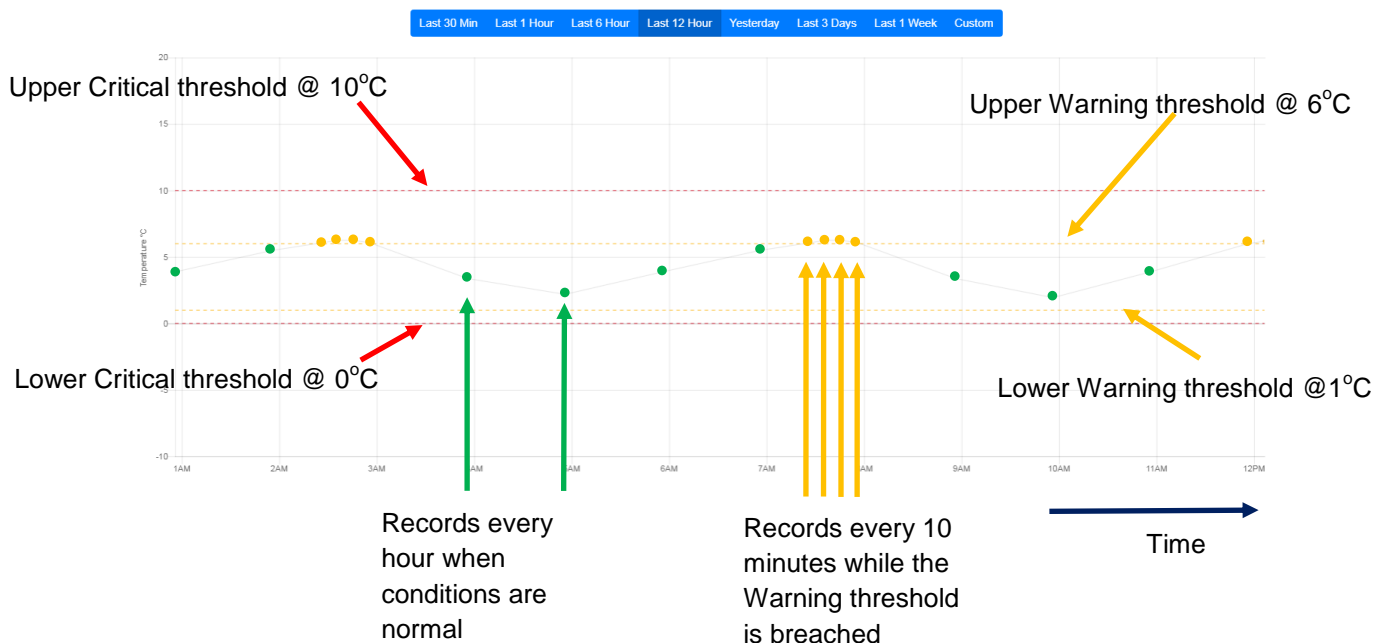
6. Modes of Operation

The DP firmware operates as a state machine and can run in a number of modes.

1) RUN Mode [ACTIVE]

This is the deployment mode where the DP spends most of its time in ultra low power sleep mode. Periodically, (at a settable interval) the DP wakes to **CHECK** its sensor values against preset alarm limits. Should any value be outside these limits, a log record will be created and (if enabled) the DP will immediately transmit an alert. In most applications, conditions are predominately normal and this **unique feature** allows monitoring to be performed intensively without undue battery use or the unwanted creation of large data sets. At a separate interval, the DP wakes and always **LOGs** its sensor values into local memory.

An example of this feature in action is shown below:



The above is color coded with Normal in **GREEN**, Warning in **AMBER** and Critical in **RED**.

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At an independently settable interval, the DP wakes to **FLUSH** the above log **records** to an internet database using LoRaWAN (or NB-IOT). Note that communications are always duplex. That is, a remotely deployed DP can receive new instructions and settings from the internet database.

[At a further independently settable interval (& if enabled), the DP will turn on its Bluetooth module. This allows for an **alternative** automated means to **flush** log records to local devices such as smart phones or tablets.]

The DP can also be woken at any time by a number of interrupts:

- a) The push button is pressed.
- b) An optic event occurs.
- c) A wired door ajar event occurs.
- d) An external device is plugged in.

2) BLUETOOTH Mode [ACTIVE]

In this mode, the Bluetooth module is ON and advertising to solicit connections from any local device. The QR code on the front label of the DP provides an easy means to install the Bluetooth App and connect to the DP.

The Bluetooth App provides access to all DP settings and with the correct permissions a user may customize the settings.

Fail Safe - Note that if a Bluetooth connection is terminated or never made then after a short **timeout**, the DP automatically returns to **RUN** mode.

3) OFF Mode [INACTIVE]

In this mode, everything is OFF except the push button. The power consumption is now so low that the batteries can be left connected and will last for > 10 years. In this mode, **a shipping lock** can be applied by pressing the push button 20 times. When the shipping lock is ON, a power cycle reboot caused by temporary battery disconnection during transport **cannot** cause the DP to **activate**. This mode is suitable for air freight and could be termed "flight mode".

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4) CALIBRATION Mode



[ACTIVE]

When a calibration dongle is plugged in, it is auto detected and the DP enters calibration mode. The DP follows instructions read from the dongle and performs a custom calibration procedure accordingly. That is, the number of calibration points (from 1 to 10) to be acquired and the sensors to be calibrated (temperature only OR temperature and humidity). A calibration dongle also includes its own temperature and humidity sensors and their traceable calibration references. When equilibration of both the DP and dongle sensors has been reached, a calibration point is acquired by the DP.

Worked example for a 1 point field calibration

1. User plugs the dongle into a DP in situ [e.g. in a freezer @ -20°C]
2. User sees **CAL** on the DP display
3. User leaves to equilibrate
4. User sees **End** on the DP display
5. User unplugs the dongle
6. At the next transmission interval, the DP sends calibration data to the online servers and renews its calibration certificate.

The system also supports multi point and multi sensor calibration procedures. In this case, the user is prompted to move the DP and dongle to the next calibration point by seeing **nxt** on the DP display. They repeat until they see **End** on the DP display.

NOTES

Fail Safe - the calibration procedure has a timeout and any DP automatically returns to RUN mode even if the dongle is left in place.

Does not require expensive calibration chambers – precision setting of the actual calibration points is not a requirement – only stable conditions at each point.

This unique feature is patented.

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5) Use of the push button to show status and change modes

The push button has a “click and pause” interface. After display indications, the DP returns to its current mode or changes mode as described below.

In **RUN** mode:

If the button is pressed **once** then the DP display shows **__1**, then the current temperature (e.g. **-20C** or **- 4F**), then the current humidity (e.g. **H77**), then **Bat**, then the current battery voltage (e.g. **2.7**).

If enabled in settings, then a time stamped log record is written. This is useful in applications where the customer requires confirmation of a **status check** action. In addition, the Bluetooth module is enabled for the “*BLE Listen for connection timeout*” (a setting).

If the button is pressed **twice** then the DP display shows **__2** then **SEn** then a LoRAWAN (or NB-IOT) transmission is made and the connection strength is indicated as a %age (from 0-100) (e.g. **45%**) then **run**.

If the button is pressed **ten** times then the DP display shows **_10** then the mode is toggled to **OFF** and the DP display shows **OFF**.

In **OFF** mode:

If the button is pressed **ten** times then the DP display shows **_10** then the mode is toggled back to **RUN** and the DP display shows **run**.

For <10 button presses, then the DP returns to hibernation and the DP display shows **OFF**.

If the button is pressed **twenty** times then the DP display shows **_20** then the **shipping lock** is applied and the DP display shows **LOC**.

When the shipping lock is ON, then for all button presses <20 the DP returns to hibernation and the DP display shows **LOC**.

If the shipping lock is ON and the button is pressed twenty times then the DP display shows **_20** then the shipping lock is toggled OFF, the DP returns to hibernation and the DP display shows **OFF**.

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In **CALIBRATION mode**:

The push button is inactive.

NOTES.

When in BLUETOOTH mode and connected to the App, the App provides the user with full mode control.

Calibration of the thermocouple input is performed using the Bluetooth App. A handheld thermocouple calibrator is plugged into the thermocouple socket. Up to 10 calibration points may be entered. In this case the App connects to the online servers and renews the calibration certificate.

The Bluetooth App also supports FUOTA (Firmware Update Over The Air).

7. Components and Certifications

1) CPU

The DP is driven by an STM32 microcontroller from ST Microelectronics (STM32L072RZT6)

<https://www.st.com/en/microcontrollers-microprocessors/stm32l072rz.html>

ST Microelectronics are a world leader in microcontrollers. The STM32L072RZT6 is both readily available and part of an established and wide range of microcontrollers.

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2) LoRaWAN Radio

The DP uses a pre certified module based on a Semtech SX1276

<https://www.semtech.com/products/wireless-rf/lora-connect/sx1276>

The CE, FCC, Canadian and Japanese certificates are available on request.

Semtech are the world leader in LoRaWAN technology. There are a wide range of manufacturers producing pre certified modules suitable for use. All parts are readily available.

3) NB-IOT Radio

The DP uses a pre certified module based on a Nordic[®] Semiconductor

<https://www.nordicsemi.com/Products/nRF9160>

4) Bluetooth Radio

The DP uses a pre certified module based on a Nordic[®] Semiconductor nRF52810 SoC solution.

<https://www.nordicsemi.com/products/nrf52810>

The CE, FCC, Canadian and Japanese certificates are available on request.

5) Batteries

Any AA batteries may be used to power the DP.

The DP features power conditioning which guarantees a constant 3.3V supply down to an input voltage of 0.7V [i.e. 0.35V per battery]. This means that all sensor measurements remain accurate and wireless transmission power is constant at all times.

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Standard AA batteries are both readily available worldwide and may be disposed of into general waste. This is an important feature for self maintenance by the end user.

The Lithium Polymer rechargeable battery option is certified to IEC62133-2:2017 and is CE marked. This can be recharged either from a USBA cable or using Qi wireless charging. The Lithium battery option is best if the DP is in temperatures below -25°C .

The DP logs and reports its battery voltage regularly and the power conditioning circuitry allows for early warning alerts to be issued well in advance of battery depletion. A coulomb counting algorithm is under development to provide an automated calculation of the % of battery remaining at all temperatures.

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