PCT200

Powercast® High-Function RFID Sensor Datalogger

DESCRIPTION

The PCT200 RFID Sensor Tag is a high-functioning,datalogging RFID tag capable of measuring temperature, humidity, and light level with high accuracy. It contains a wirelessly rechargeable battery to enable long lasting data logging capabilities while outside of the RFID reader's field. Its customizable data reading capabilities can be easily set through a user friendly interface. The tag harnesses the capability of the Powercast Powerharvester® Chipset to recharge the on-board battery while the data is being downloaded. The sensor measurements can be read back out of the tag's memory using any standard UHF RFID reader. Powercast's technology enables a completely maintenance-free sensing and tracking solution for UHF RFID applications.

FEATURES

- EPC Class 1 Gen 2 compliant
- ISO/IEC 18000-6C compliant
- 10 meter read range
- High sensor accuracy
- "Find Tag" feature – locate one specific tag by illuminating an on-board LED
- Wide RF range: -17dBm to +20dBm
- Frequency range: 860MHz to 960MHz
- Compact hard case packaging
- RoHS compliant
- High RF to DC conversion efficiency - up to 75%
- -20 to +60C operational temperature range
- Up to 1 month of battery life
- Onboard button to start/stop logging
- Battery is recharged using the RFID reader's field
  (No wires to plug in, no batteries to change)
- Customizable data read times from 1 minute to 1 hour
- Stores maximum, minimum, and average values in user memory
- Read times and dates are available along with sensor data

APPLICATIONS

- Medical Asset Tracking and Monitoring
- Smart Grid
- Building Automation
- Logistics
- Asset Monitoring
- Supply Chain Management
- Materials Management
- Industrial Monitoring

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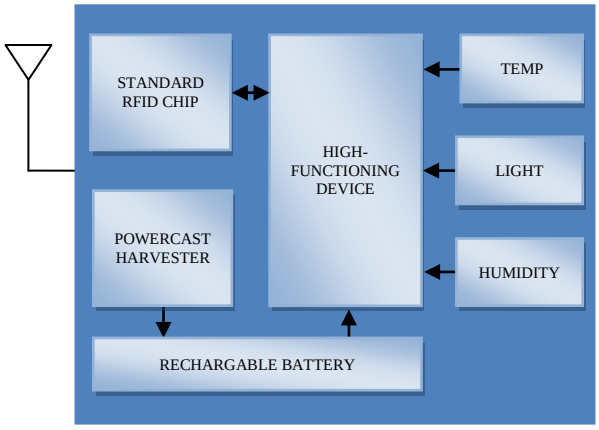
Functional Block Diagram



ABSOLUTE MAXIMUM RATINGS

T_A = 25°C, unless otherwise noted.

Parameter	Value	Unit
RF Input Power	+23	dBm
Operating Temperature Range	-20 to 60	°C
Battery Charging Temperature Range	0 to 60	°C
Storage Temperature Range	-20 to 60	°C

Exceeding the absolute maximum ratings may cause permanent damage to the device.

SPECIFICATIONS

T_A = 25°C, RF_{IN} = 915MHz unless otherwise noted.

Parameter			Min	Typ	Max	Unit
RF Characteristics[1]						
Input Power			-17		+20	dBm
Frequency			860	915	960	MHz
Read Distance			0	5	10	m
Sensor Read Time			15.3	3600	86,400	s
Temperature						
Range			-20	-	60	°C
Accuracy			-	±2%	-	
Light						
Range			0	-	1000	Lux
Accuracy			-	±10%	-	
Humidity						
Range	> -20°C		0	-	100	
Accuracy			-		-	%RH
	11% to 89%			±4%		
	0 to 10% or 90% to 100%			±8%		
Battery Life*			5	14	28	Days
Recharge Time (at 1m)			10	16	24	Hours

*Device runtime will decrease as temperature decreases

FUNCTIONAL DESCRIPTION

OVERVIEW

The tag operates by waking up approximately every 15s and checking user programmable flags in memory. These flags determine the tags' behavior. Depending on how the flags are configured, the tag will do one or more of the following:

1. Go back to sleep
2. Erase the memory
3. Perform the locate operation
4. Update maximum and minimum sensor reads
5. Update the logged averages and current sensor reads.

Sensor reads are taken at user defined intervals from 15s to one day (24 hours) and are settable via the **wakeUpDuration** word. The sensor values are stored in the RFID chip's memory so that the values can be read out even if the tag loses power. The tag is equipped with a button and a switch that start/stop logging and disconnect the battery respectively.

INITIAL POWER ON PROCEDURE

The following steps should be carried out anytime the switch on the PCT200 is turned on. After turning the switch to the on position the tag **MUST** be placed in an RF field. This will put the PCT200 into normal operation. By default, the tag will come up with all the flag bits set to 0. This is to prevent the data on the tag from being erased.

NOTE: if the tag is now set to run mode either by the reader or pressing the button, the logging data will be overwritten.

POWER

The PCT200 tag is powered from an onboard rechargeable battery. The battery life ranges from 5 days to 28 days depending upon how often the tag is set to check in, which is adjustable by the user. The tag utilizes Powercast's harvesting technology to harvest the RF energy produced by an RFID reader and efficiently convert it into usable DC Power to recharge the battery. Therefore, anytime that the tag is in the RF field, the battery is being recharged. Recharge time typically take between 8 and 12 hours depending the current state of the battery and how close to the reader that tag is. The LED will blink quickly two times when the battery is full.
To prevent permanent battery damage it is recommended to recharge the battery every 2 months when not in use.

NOTE: If the tag will not be used for an extended period of time, the onboard switch must be turned off to prevent damage to the battery.

SENSOR READS

The PCT200 has the option to sense temperature, light, and humidity or any combination of the three. There is also a find tag only version. The rate at which sensor reads are taken is adjustable by the user and can range from 15s to one day (24 hours) in 15s increments. See **WAKEUP DURATION** for instructions on how to set the check in time.

SENSOR TIMES

The tag stores an approximate corresponding time associated with each maximum and minimum sensor read. To get the sensor times, add one to the value read from the tag and multiply it by 15.3 s and add it to the start time.

SENSOR DATA

The PCT200 will store:

- The 5 maximum and 5 minimum values and their respective read times for each sensor
- The current sensor read values
- The averages of all the sensor read values

The averages and current values are updated twice per day or on demand by setting the correct flag. The memory location for each sensor read is listed in *Table 1*. The data is stored as a hexadecimal value between 0 and 1023. See section entitled *Conversion Formulas* for information on how to convert these values to their corresponding sensor values.

MEMORY CLEAR

The sensor data can be reset using the flags on the tag. This enables the tag to be used multiple times for different applications. This will cause all of the logged sensor data to be permanently deleted. The start time must always be written to the tag after every memory clear. See section entitled "**FLAGS**" for more information.

BUTTON

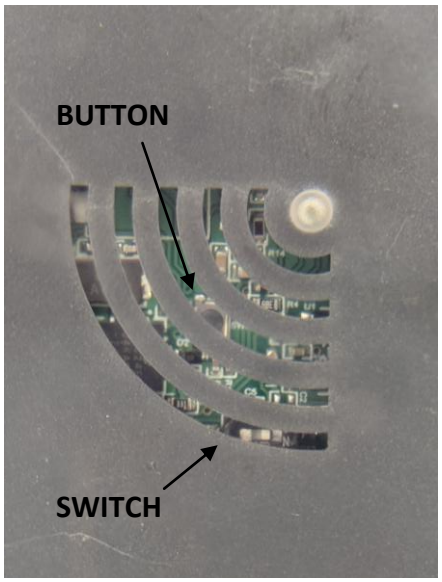
The PCT200 is equipped with a button to start and stop logging data. Pressing the button performs the same function as toggling the Start/Stop bit of the Flags in user memory location 04h.

SWITCH

The PCT200 is also equipped with a switch. The switch is used to completely disconnect the onboard battery. During shipping and storage, the switch should be turned to the off position to prevent the battery from draining. The switch must be turned on and the device must be placed in the RF field before the tag will operate.

LOCATE TAG

The PCT200 is equipped with a locate tag feature. This helps to find a tag in the field when there are multiple tags. It causes the LED on the tag to blink so that the user can find it.



DATA RETRIEVAL

The tags are compatible with EPC Gen2 commands. Data should be read in 16 bit words. The user data is stored in the user memory locations (memory bank 3) starting at byte 00h. The data values will range from 0 to 1023.

Table 1: Sensor Memory Locations

WORD	MEMORY ADDRESS	CONTENT	DATA SOURCE	DATA SINK	ERASED ON CLEAR	CRC
0	00h	Product ID	PCT200	User	No	No
1	02h	Product Configuration	PCT200	User	No	No
2	04h	Flags	User	PCT200	No	No
3	06h	Wake Up Duration	User	PCT200	No	No
4	08h	RESERVED	-	-	-	-
5	0Ah	Start Time	User	User	No*	No
6	0Ch	Start Time	User	User	No*	No
7	0Eh	Battery Voltage	PCT200	User	Yes	No
8	10h	Maximum ADC Read of Temperature 1	PCT200	User	Yes	Yes
9	12h	# of wakes since start	PCT200	User	Yes	Yes
10	14h	Maximum ADC Read of Temperature 2	PCT200	User	Yes	Yes
11	16h	# of wakes since start	PCT200	User	Yes	Yes
12	18h	Maximum ADC Read of Temperature 3	PCT200	User	Yes	Yes
13	1Ah	# of wakes since start	PCT200	User	Yes	Yes
14	1Ch	Maximum ADC Read of Temperature 4	PCT200	User	Yes	Yes
15	1Eh	# of wakes since start	PCT200	User	Yes	Yes
16	20h	Maximum ADC Read of Temperature 5	PCT200	User	Yes	Yes
17	22h	# of wakes since start	PCT200	User	Yes	Yes
18	24h	Minimum ADC Read of Temperature 1	PCT200	User	Yes	Yes
19	26h	# of wakes since start	PCT200	User	Yes	Yes
20	28h	Minimum ADC Read of Temperature 2	PCT200	User	Yes	Yes
21	2Ah	# of wakes since start	PCT200	User	Yes	Yes
22	2Ch	Minimum ADC Read of Temperature 3	PCT200	User	Yes	Yes

23	2Eh	# of wakes since start	PCT200	User	Yes	Yes
24	30h	Minimum ADC Read of Temperature 4	PCT200	User	Yes	Yes
25	32h	# of wakes since start	PCT200	User	Yes	Yes
26	34h	Minimum ADC Read of Temperature 5	PCT200	User	Yes	Yes
27	36h	# of wakes since start	PCT200	User	Yes	Yes
28	38h	Maximum ADC Read of Humidity 1	PCT200	User	Yes	Yes
29	3Ah	# of wakes since start	PCT200	User	Yes	Yes
30	3Ch	Maximum ADC Read of Humidity 2	PCT200	User	Yes	Yes
31	3Eh	# of wakes since start	PCT200	User	Yes	Yes
32	40h	Maximum ADC Read of Humidity 3	PCT200	User	Yes	Yes
33	42h	# of wakes since start	PCT200	User	Yes	Yes
34	44h	Maximum ADC Read of Humidity 4	PCT200	User	Yes	Yes
35	46h	# of wakes since start	PCT200	User	Yes	Yes
36	48h	Maximum ADC Read of Humidity 5	PCT200	User	Yes	Yes
37	4Ah	# of wakes since start	PCT200	User	Yes	Yes
38	4Ch	Minimum ADC Read of Humidity 1	PCT200	User	Yes	Yes
39	4Eh	# of wakes since start	PCT200	User	Yes	Yes
40	50h	Minimum ADC Read of Humidity 2	PCT200	User	Yes	Yes
41	52h	# of wakes since start	PCT200	User	Yes	Yes
42	54h	Minimum ADC Read of Humidity 3	PCT200	User	Yes	Yes
43	56h	# of wakes since start	PCT200	User	Yes	Yes
44	58h	Minimum ADC Read of Humidity 4	PCT200	User	Yes	Yes
45	5Ah	# of wakes since start	PCT200	User	Yes	Yes
46	5Ch	Minimum ADC Read of Humidity 5	PCT200	User	Yes	Yes
47	5Eh	# of wakes since start	PCT200	User	Yes	Yes
48	60h	Maximum ADC Read of Light 1	PCT200	User	Yes	Yes
49	62h	# of wakes since start	PCT200	User	Yes	Yes

50	64h	Maximum ADC Read of Light 2	PCT200	User	Yes	Yes
51	66h	# of wakes since start	PCT200	User	Yes	Yes
52	68h	Maximum ADC Read of Light 3	PCT200	User	Yes	Yes
53	6Ah	# of wakes since start	PCT200	User	Yes	Yes
54	6Ch	Maximum ADC Read of Light 4	PCT200	User	Yes	Yes
55	6Eh	# of wakes since start	PCT200	User	Yes	Yes
56	70h	Maximum ADC Read of Light 5	PCT200	User	Yes	Yes
57	72h	# of wakes since start	PCT200	User	Yes	Yes
58	74h	Minimum ADC Read of Light 1	PCT200	User	Yes	Yes
59	76h	# of wakes since start	PCT200	User	Yes	Yes
60	78h	Minimum ADC Read of Light 2	PCT200	User	Yes	Yes
61	7Ah	# of wakes since start	PCT200	User	Yes	Yes
62	7Ch	Minimum ADC Read of Light 3	PCT200	User	Yes	Yes
63	7Eh	# of wakes since start	PCT200	User	Yes	Yes
64	80h	Minimum ADC Read of Light 4	PCT200	User	Yes	Yes
65	82h	# of wakes since start	PCT200	User	Yes	Yes
66	84h	Minimum ADC Read of Light 5	PCT200	User	Yes	Yes
67	86h	# of wakes since start	PCT200	User	Yes	Yes
68	88h	Current Temperature	PCT200	User	Yes	Yes
69	8Ah	Current Humidity	PCT200	User	Yes	Yes
70	8Ch	Current Light	PCT200	User	Yes	Yes
71	8Eh	RESERVED	-	-	Yes	Yes (0000h)
72-73	90h	Average Temperature	PCT200	User	Yes	Yes
74-75	94h	Average Humidity	PCT200	User	Yes	Yes
76-77	98h	Average Light	PCT200	User	Yes	Yes
78	9Ch	# of wake ups	PCT200	User	Yes	Yes
79	9Eh	CRC	PCT200	User	Yes	-

PRODUCT ID AND CONFIGURATION

The product ID code for the PCT200 is 200 (C8h). For the PCT100 tag, it will be 100 (64h). The product configuration is dependent upon which sensors are populated. It is a binary code where 1 represents the sensor being populated and 0 represents the sensor being absent.

Table 2: Product Configuration

Bit 2	Bit 1	Bit 0
Temperature	Light	Humidity

For Example, if temperature and humidity are populated and light is not, the product ID would be 101b or 5h.

FLAGS

The flags are used to control operation of the tag.

Bit	Description	Values
0	Start/Stop	0-Stop 1-Start
1	Erase Memory	1-Clear
2	Locate	1-Locate
3	Update Averages	1-Update Averages
4	RESERVED	
5	RESERVED	
6	RESERVED	
7	RESERVED	

START/STOP

The tag will remain in sleep mode until the run bit is set to 1 either using an RFID reader or pressing the onboard button. Once it is running, it will take all of the sensor readings, update the RFID chip, and go to sleep for the **wakeUpDuration**. It will wake up every 15s to check the flags. It will stay in this loop until the run bit is set to 0. When the run bit is set to 0, all the ADC reads can still be read out from the tag, but no new values will be populated.

ERASE MEMORY

When set to 1, the tag will erase all values from word 7 onward, including the **count** that relates the sensor reads to the start time. Because of this, the start time must be written to the tag every time the memory is cleared. After the memory is cleared the Erase Memory flag will automatically be set back to 0 and the LED will blink twice. The tag will then continue checking the rest of the flag bits and will resume whatever mode it was in prior to locate.

LOCATE

The locate feature is activated by setting the locate bit high. The LED will blink for 10s. Afterward, the locate bit is automatically set back to 0. The tag will then continue checking the rest of the flag bits and will resume whatever mode it was in prior to locate.

UPDATE AVERAGES

The averages are automatically sent to the RFID chip for reading twice per day, regardless of what the Update Averages flag is set to. The user can also request that the averages be updated on demand by setting the Update Averages flag to high. This is done to preserve battery life and limit the number of writes to the RFID chip memory. Afterward, the Update Averages flag is automatically cleared. The tag will then continue checking the rest of the flag bits and will resume whatever mode it was in prior to locate.

WAKEUP DURATION

The wake up duration is user settable. It tells the tag how often to take the sensor reads. It will be 15.3s multiplied by the user set value. For example, if the **wakeUpDuration** field is set to 10, the tag will take sensor readings every 150.3s. The **wakeUpDuration** is checked every 15.3s by the tag.

START TIME

The start time is stored in words 5-6 on the tag. It uses 32-bit POSIX time, which is the number of seconds from EPOC. The time-zone is UTC+0. The count associated with each sensor read is multiplied by 15.3s and added to this start time to get a rough idea of when each sensor read was taken.

SENSOR ADC READS

The sensor read results are integers between 0 and 1023 and can be converted using the equations in the CONVERSION FORMULAS section below. If a sensor is not populated, the ADC value will be read as 1111 11XX XXXX XXXX in binary.

The word directly following a sensor ADC read is the count corresponding to that read. To determine when a sensor read was taken, add one to the count and multiply it by 15.3s. Then, add this value to the start time. If a sensor is not populated, the value will be read as 0000h.

CURRENT SENSOR VALUES

The current sensor values, like the averages, are written to the RFID chip twice per day. You can get the current values on demand by setting the corresponding flag bit high. The current ADC reads are converted using the same formulas as the normal sensor reads.

AVERAGE VALUES

The average values are stored on the RFID tag using an unsigned Q 10.22 format. The average values must be bitwise shifted to the right by 22 bits. The remaining value can be converted using the same formulas below.

CYCLIC REDUNDANCY CHECK

The averages, current values, and wake count (word addresses 88h to 9Dh inclusive) can be verified using the cyclic redundancy check *ITU X.25 FCS*. This checksum value is available in memory bank 3 (user memory) at word address 9Eh. It is represented in big-endian order with the most significant bit first.

For more information, see Section 2.2.7.4 in *ITU-T Rec. X.25 (10/96) Interface between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) for terminals operating in the packet mode and connected to public data networks by a dedicated circuit*.

CONVERSION FORMULAS

The values for each sensor read will be integers between 0 and 1023 in decimal and stored on the RFID chip as hexadecimal values. The following are the formulas to convert these values into their respective sensor values.

- TEMPERATURE

For temperature, the formula will convert the values read into a resistance.

$$R(k\Omega) = \frac{10 * X}{1024 - X}$$

Where X is the decimal value read from the tag. The resistance value must then converted into temperature using the look up table in **Table 1**. If the resistance falls between two values, a linear approximation between the two closest values should be made.

Table 1: Resistance to Temperature

Resistance (kΩ)	Temperature (°C)	Resistance (kΩ)	Temperature (°C)
195.652	-40	4.917	45
148.171	-35	4.161	50
113.347	-30	5.535	55
87.559	-25	3.014	60
68.237	-20	2.586	65
53.65	-15	2.228	70
42.506	-10	1.925	75
33.892	-5	1.669	80
27.219	0	1.452	85
22.021	5	1.268	90
17.926	10	1.11	95
14.674	15	0.974	100
12.081	20	0.858	105
10	25	0.758	110
8.315	30	0.672	115
6.948	35	0.596	120
5.834	40	0.531	125

- LIGHT

$$Ill.(Lux) = -1.2648 * X + 1216$$

Where X is the decimal value read from the Tag.

Note: The Light equations for the PCT100 and PCT200 are different.

- HUMIDITY

$$\%RH = \frac{1}{0.00636}\left(\frac{X}{1024} - 0.1515\right)$$

Where X is the decimal value read from the tag.

Please see the PCT Conversions document.

- SENSOR TIME

$$Read\ Time = (X + 1) * 15.3s + Start$$

Where X is the value read from the tag in decimal and start is the start time stored in words 5 and 6.

Note: All times are approximate.

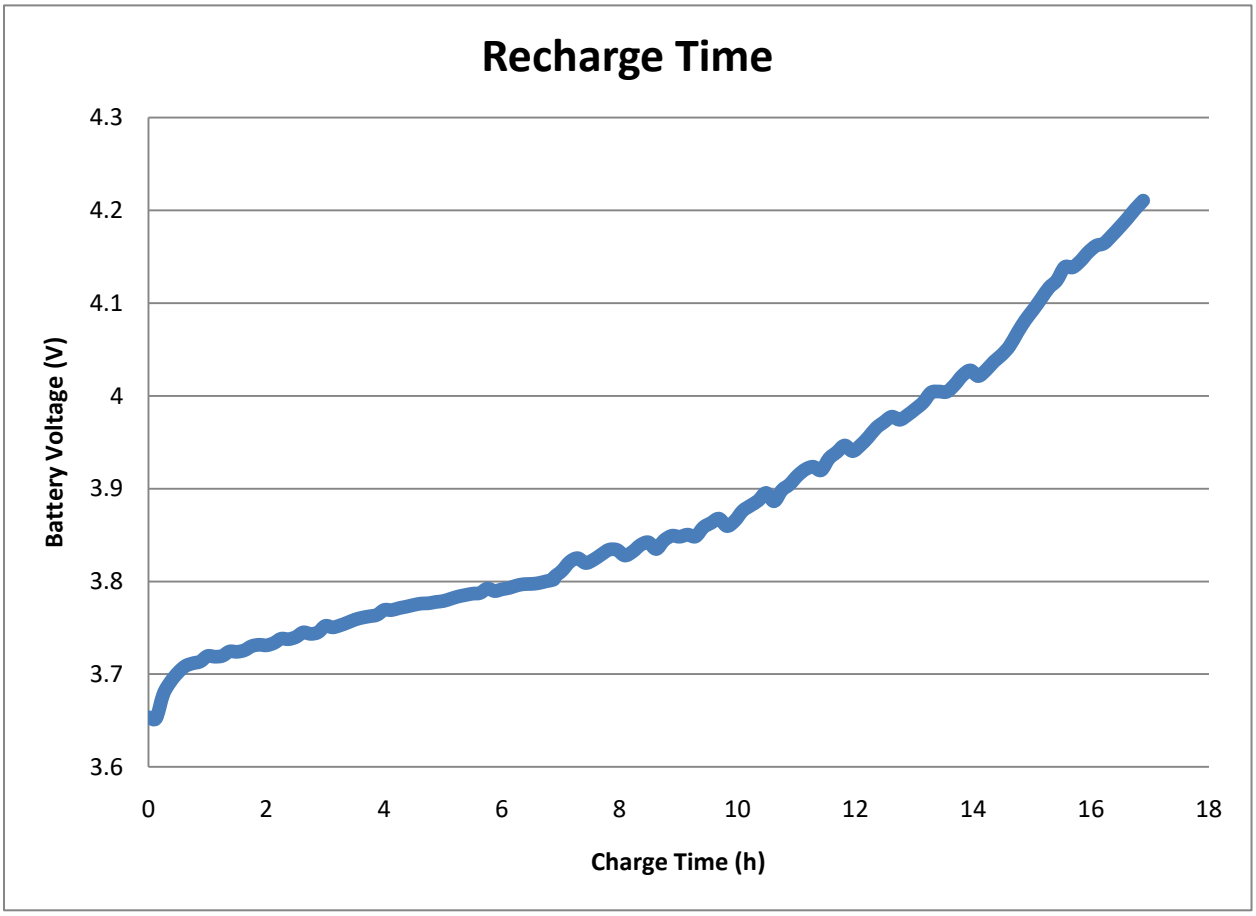
- BATTERY VOLTAGE

The battery voltage will range from 3.6V to 4.2V. The formula to calculate is

$$Battery\ Voltage = \frac{ADC * 6}{1024}$$

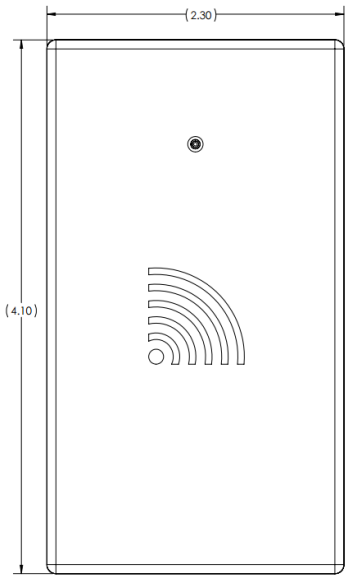
BATTERY RECHARGING INFORMATION

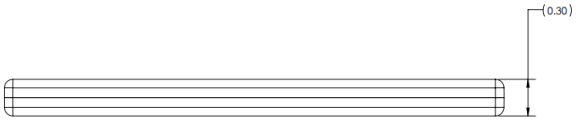
The data below illustrates the battery being recharged using a standard UHF RFID reader at a distance of 1m at room temperature. Factors that affect the recharge time are tag orientation, reader output power and the distance between the PCT200 and the reader's antenna. For optimal charge time, the tag should be oriented parallel to the RFID antenna. If the onboard switch is not in the on position, the battery will not charge.



Note: Battery recharge time is effected by temperature and the battery should not be recharged at temperature of less than 0°C.

Mechanical Specifications





All Dimensions in inches

P2110 MODULE SERIES

PCT 2 00 - XYZ

PCT Tag series	Version **100** = Battery Free **200** = Datalogging	XYZ (Sensors Desired) **T**= Temperature **H**=Humidity **L** = Light **F** = Find Tag Only

PCT100-T	Temperature
PCT100-L	Light
PCT100-H	Humidity
PCT100-TL	Temperature and Light
PCT100-TH	Temperature and Humidity
PCT100-LH	Light and Humidity
PCT100-TLH	Temperature, Light and Humidity
PCT200-T	Temperature
PCT200-L	Light
PCT200-H	Humidity
PCT200-TL	Temperature and Light
PCT200-TH	Temperature and Humidity
PCT200-LH	Light and Humidity
PCT200-TLH	Temperature, Light and Humidity

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