

CTC PRO

WA 100 Series

WIRELESS APPLICATION



**PROTECTION & RELIABILITY
INSTRUMENTS**



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Thank you for your purchase of CTC's Wireless transmitter system. This document outlines various ways to interact with your new transmitters. Please refer to the following sections based upon the needs of your setup. Additionally, contact your CTC sales representative for information on how to download our application, or the open source code if you plan to use your own programs to communicate with CTC Wireless transmitters.

CTC Wireless Application Users - If you plan to use CTC's software (including use of the WA100 tablet) as the primary way of taking and viewing readings from CTC wireless sensors. CTC software contains an easy way to view time-waveforms and FFTs, as well as organize transmitters, sensors and receivers. Please refer to pages 8-27 of the manual.

Standalone Reader Users – If you plan on using our command-line software only to create datafiles that will be consumed by your own systems. Our software stores these datafiles in a json format, and it is assumed that customers will have a procedure to read/process these files as readings into their own systems. Please refer to pages 28-36 of the manual.

Raw BLE Data Users – If you plan to interface your software and platforms directly with WA100 transmitters on a raw Bluetooth level. Please refer to pages 37-66 of the manual.



CTC Wireless Application

Requirements

- Windows 10 minimum build version: 1703
- Administrator Privileges
- Bluetooth® 4.0 Receiver Built-in or Dongle
- Microsoft SQL Server 2012 or above (See Below)
- Approximately 1Gb of free storage (5Gb recommended) to create application files, log files, and database records

Embedded Server Mode Requires SQL Server

This software has several different configurations. The default configuration is to run an embedded API server, which requires Microsoft SQL Server. If you need a free version of Microsoft SQL Server, copy and paste this link into your browser (<https://www.microsoft.com/en-us/sql-server/sql-server-downloads>) and download/install the free/specialized version "Microsoft SQL Server Express." If you already have a Microsoft SQL Server, after you install the software, please make corrections to the "Connection String" in the settings to connect to your desired server.

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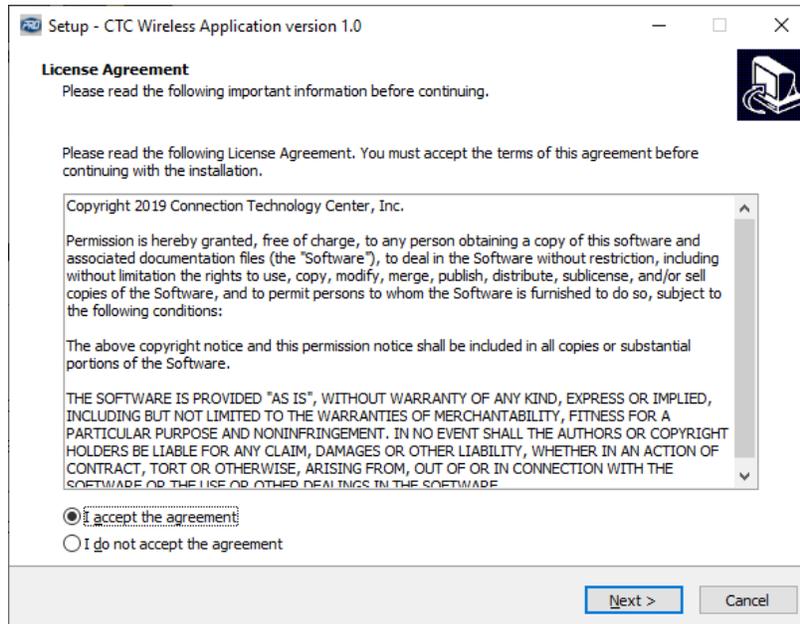
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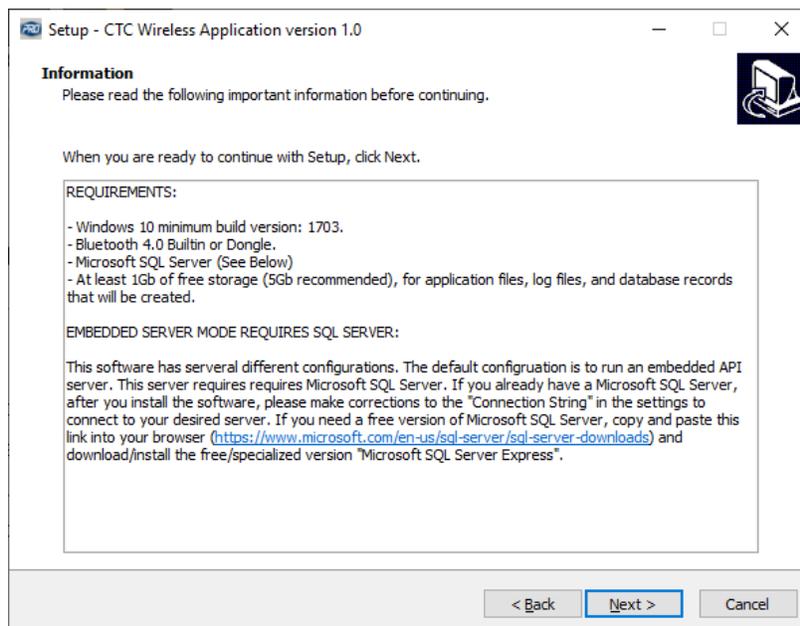


Installation

1. Run the program labeled "CTC Wireless Installer"
 - a. Please note that this installer must be run under an administrator account
 - b. Read and Accept the license -> Click Next



2. Review the requirements

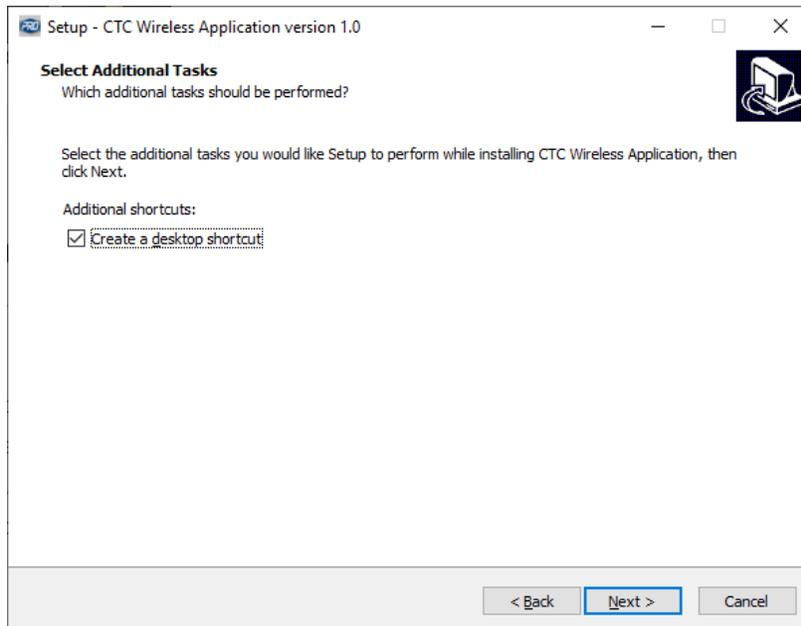


- a. A Microsoft MSSQL Server 2012 or later is required to run the software; make sure there is reserved space on an existing MSSQL database within your organization, or install the free latest MSSQL Express from the

Microsoft website <https://www.microsoft.com/en-us/sql-server/sql-server-editions-express>

b. Click Next

3. Make sure the "Create a desktop shortcut" option is selected

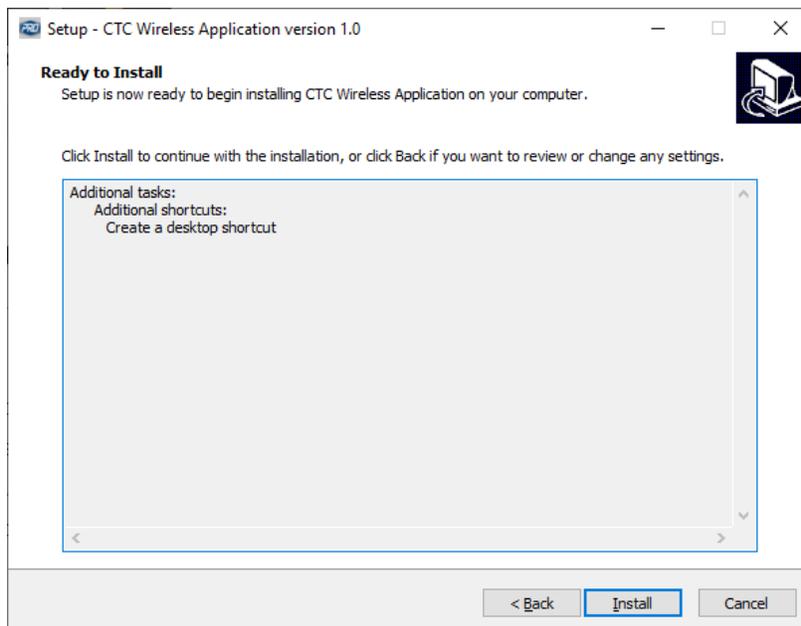


a. This will allow the user to easily enable admin privileges later

b. Click Next

4. Install the application

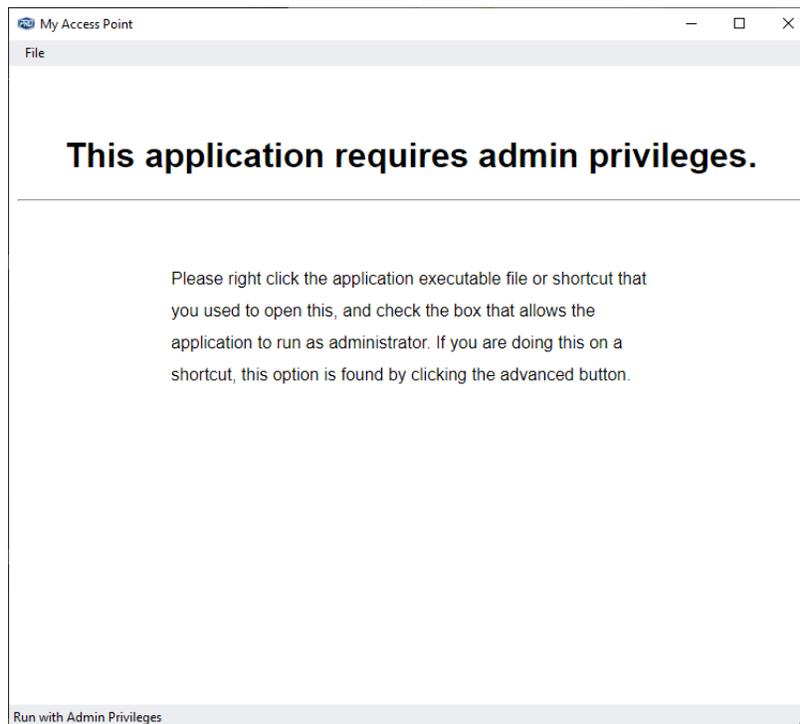
a. Click Install



Starting the Application for the First Time

The first time the application is started the Windows Firewall notification may pop up, asking the user to grant the application access to the public and private networks. It is best to allow the application access to both the private and public networks. If running the embedded server, the application may only need access to the private network, but if there is a need to change the configuration later, it would be best to give it access to both networks.

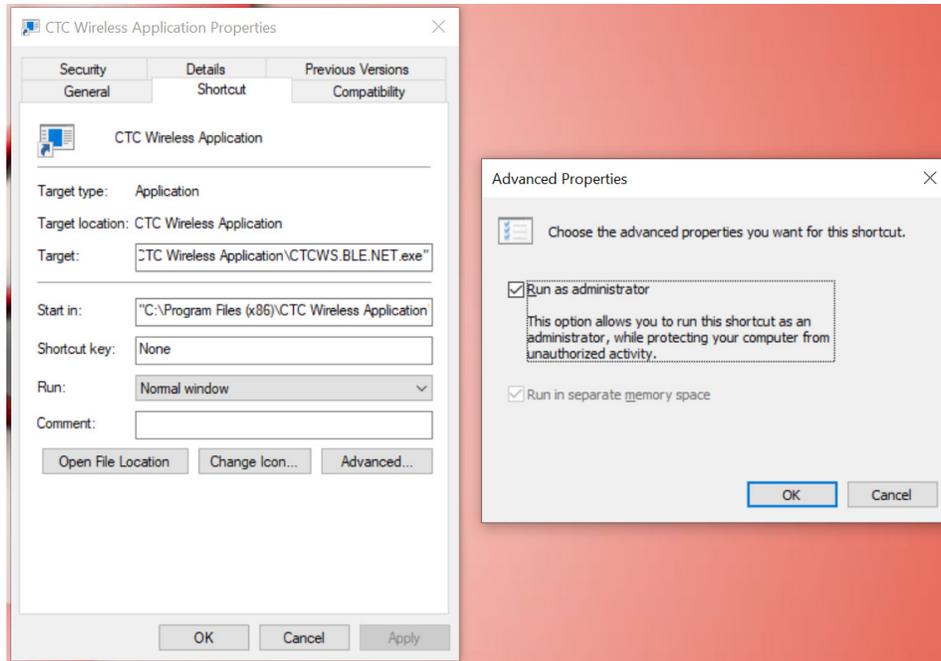
Additionally, the user may encounter a window stating that the CTC Wireless App will need to be run with administrative privileges.



The application requires administrative privileges in order to write the configuration files for the embedded server, as well as write log files for sensor readings and cached settings files for offline use.

To assign the application administrative privileges, find the desktop shortcut that the installation created, right-click it, and select properties.

In the window that pops up, click the advanced button. When the "Advanced" window pops up, check the box that says run as administrator, and click OK. Finally, click "Apply" in the original "Properties" window.



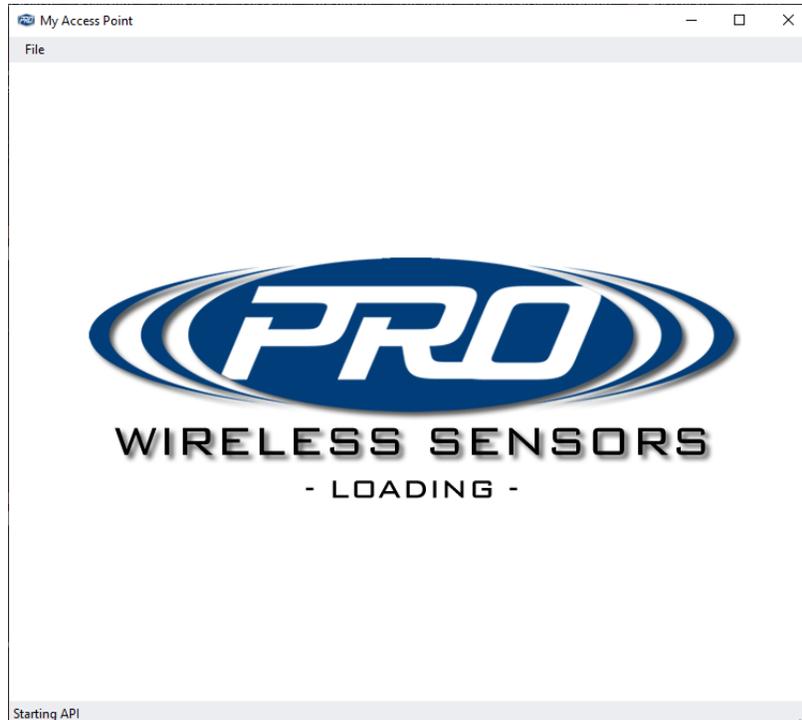
A confirmation dialog may appear that requires the user to provide administrative credentials. Click continue, and if the Windows Smart Screen pops up, type the computer’s administrative credentials into the appropriate fields.

Please note: some organizations do not allow non-administrators to install or run unsigned programs. In this event, the application will need to be installed and run under the Administrator account. Please see your system administrator or IT department if you are unable to get the program to run correctly.

The application is now ready to take readings.

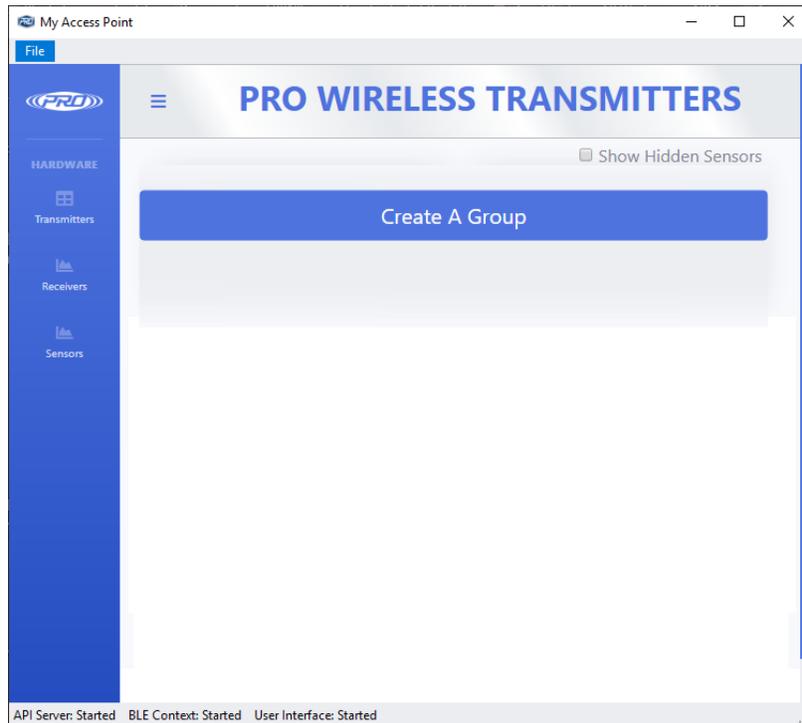
Running the application

When you run the CTC Wireless Application, the first thing that will appear is a loading screen. This screen may take up to 30 seconds on the first run, as it creates necessary directories, configures the server, starts the embedded server, and synchronizes its own configuration.

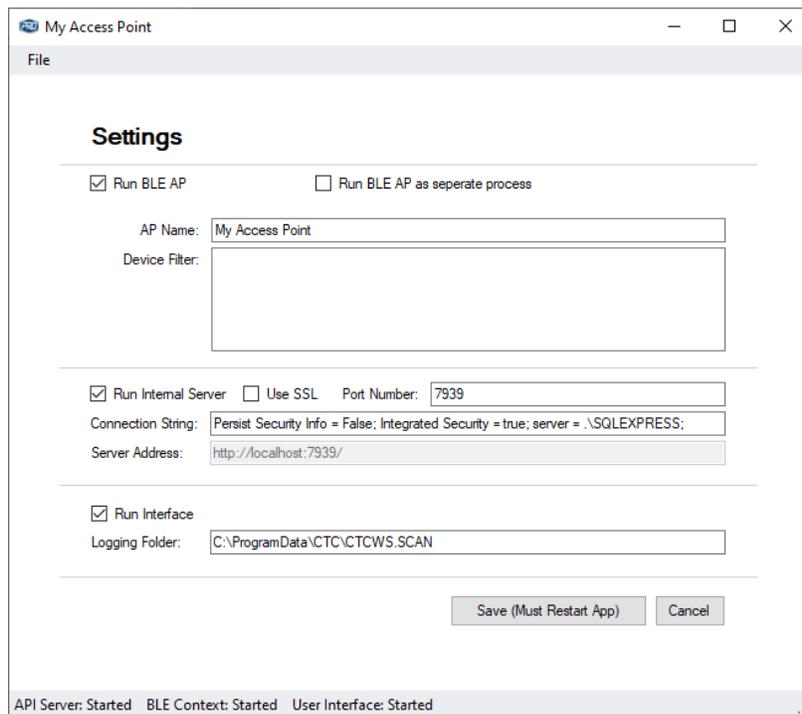


Settings

Upon Successful Install and Setup, the following window will be shown.



For the moment ignore this window and jump into the software settings screen. Choose "File" and then "Settings," to display the screen below.



To the left, there is a checklist with three main options: Run BLE AP, Run Internal Server, and Run Interface. To the right, there is a checkbox labeled "RUN BLE AP as separate process". Checking this box allows the Access Point Software to run as a separate executable on the Windows operating system. If running on a slower computer, or with many BLE devices, or even if you are having difficulty connecting to one device, running the BLE AP as a separate process can help improve performance of the application. This option may help complete readings that may otherwise get bottlenecked by other processes or slow execution on Windows.

These are the three main components of this application. They are described below in more detail.

Run BLE AP

This document will define all of the little black boxes with MIL connectors as CTC Wireless Transmitters. They have all been created using the latest Bluetooth® technology called Bluetooth® Low Energy, which appeared in the Bluetooth® specification around Bluetooth® 4.0. These transmitters all require communication with one or many central locations. We refer to these central locations as Receivers or Access Points (AP).

The first feature of the CTC Wireless Application is the Access Point. This central point has the code and workflow built into it in order to allow it to communicate with the transmitters properly. Checking the "Run BLE AP" box allows you to run this software automatically when the application starts.

When running the embedded receiver feature, the user can also assign an AP name to this software, as it will appear in the application interface with that name.

An alternative to running this feature when the software starts is to run it as a separate process. To do this, uncheck this box and run the receiver as a batch file. Please see the use cases later in this document for more details on how to do this.

Lastly, the application can be run in a separate process, but not even on the same machine, or on several other dedicated computers scattered throughout your facilities; this is also possible through said functionality.

Run Internal Server

The internal server is the second piece of the software that runs by default. To stop this, uncheck the second checkbox. All of the receiver/AP software that CTC builds has integrated functionality that understands how to communicate with our server. The server acts as a WEB API built on Microsoft's ASP.NET Core Stack.



Options are provided when running the internal software, which allow the user to turn SSL on and off. It is possible to change the port number the server runs through, or the connection string the software uses to communicate with an “MSSQL 2012+” server. Essentially, this allows the SQL server to be installed in a different location from this server or application. **Warning:** this feature uses a development certificate – it is much more secure to buy and install your own certificate on your server.

If opting not to run the embedded server, it is possible to change the “Server Address” that the rest of the software uses for sending and receiving data.

Run Interface

The last feature built into the CTC Wireless Application is the GUI or User Interface. This interface is run off the server through a single page web application, using AngularJS, Bootstrap, and other standard web front end frameworks.

The alternative to running the GUI through this application is to browse to the server address through a modern web browser like Chrome, Edge, Safari, or Firefox.

Logging Folder

In addition to the location where the application saves its settings, there is another system folder that is used to read and write configurations and pending files. This folder is called the logging folder.

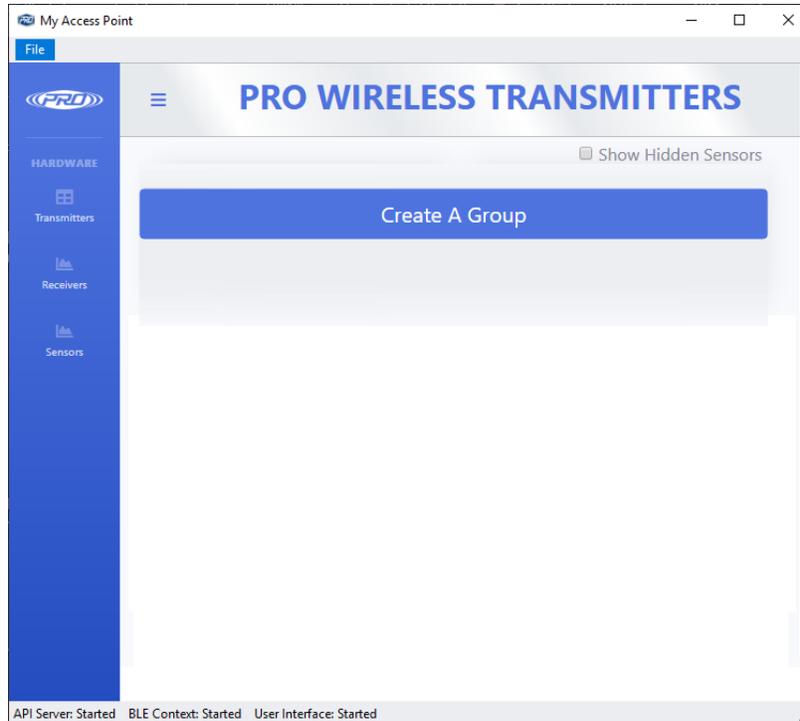
Summary

There are several ways to run this software, and it is possible to break all of the individual pieces apart and run them separately over a distributed network, in the cloud, or however is most convenient.

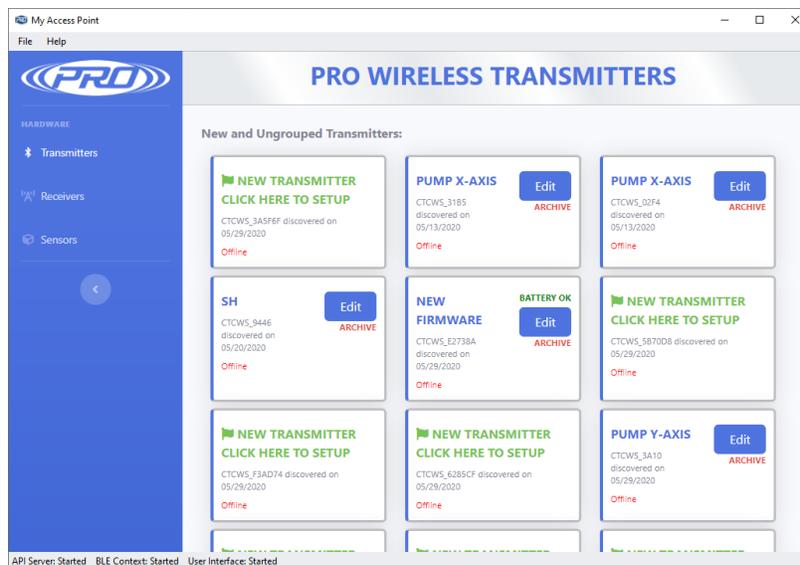


Transmitters

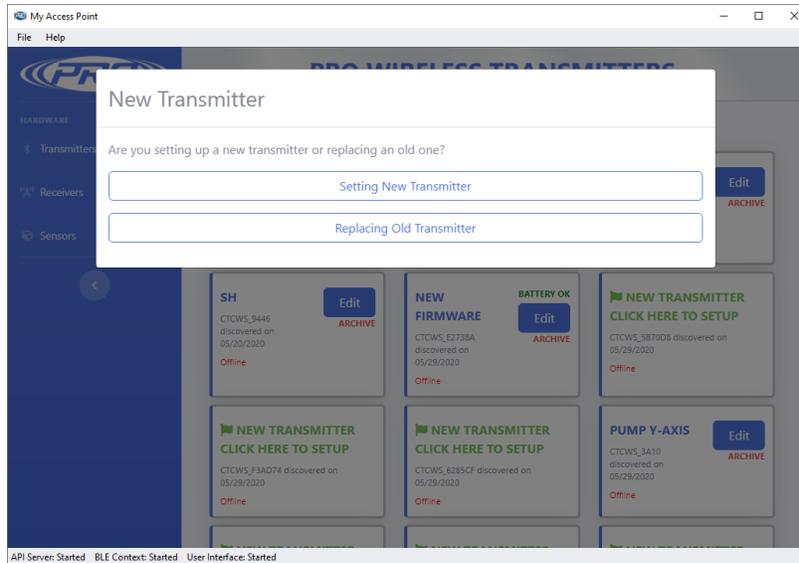
Once the program loading completes, the “Transmitters” window will be displayed. **Please note:** when discussing Transmitters, the program refers to the individual wireless connector components with which it communicates.



As the application begins to sense one or more CTC Wireless Transmitters, they will automatically start to appear, as illustrated in the example window below.



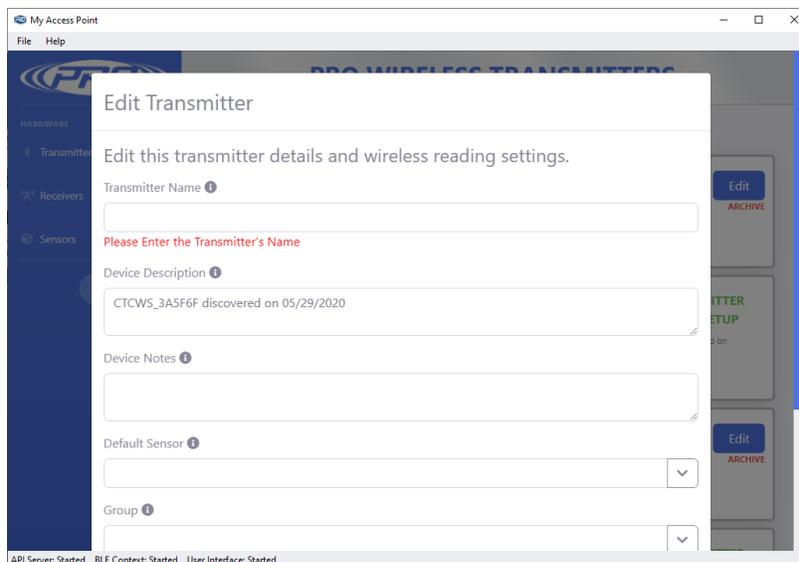
When sensors begin to appear in the application, they will appear with the text “New Transmitter Click Here to Setup.” You will not be able to use your new transmitters with this software until you have completed a short setup process.



Clicking one of the new transmitter cards will create a prompt to either set up a new transmitter or replace an old one.

Setting up a new transmitter

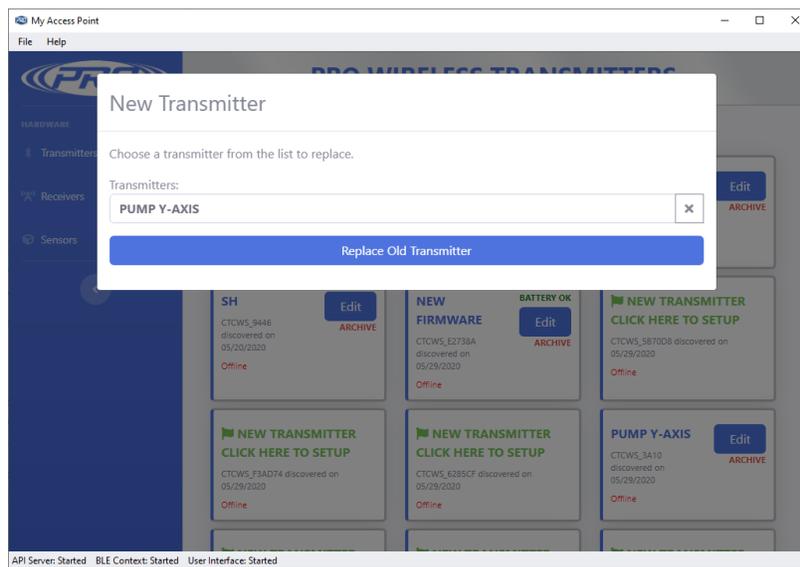
When setting up a new transmitter, the only requirement is to fill in the Transmitter Name field. Doing this and clicking the save button will allow the new transmitter to be used.



Replacing a Previous Transmitter

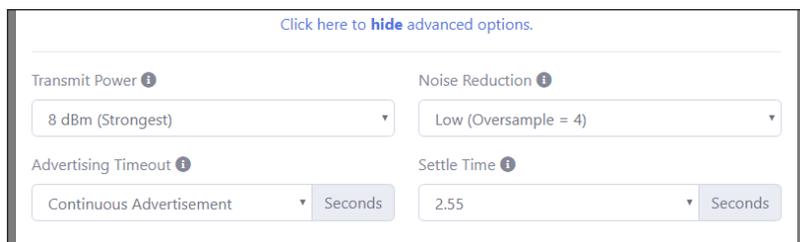
When replacing an old transmitter, the user will be asked to provide the name of the transmitter to replace. Select the old transmitter's name from the list, and click the button labeled Replace Old Transmitter.

After a brief pause, the interface will refresh, and the new transmitter will assume the role of the previous one. It will inherit all of the properties of the old transmitter, including the name. All previous readings (viewable in the readings pane) will have been automatically transferred to the new transmitter.



Advanced Transmitter Options

Lastly, on the transmitter settings screen, there is a link labeled "Click here to show advanced options." Click this to see some of the more advanced options for taking readings.



1. **Transmit Power** – the strength of the wireless signal sent from the transmitter. By default, the power is set to its highest setting of 8 dBm but can be adjusted to lower values as the situation permits. Changing to a lower value is useful to conserve battery life if the receiving device is located in very close proximity to the wireless transmitter. However, weaker signal strength reduces the overall range, and you may experience some signal loss.

2. **Noise Reduction** – the ability to produce a smooth signal output by averaging signal readings. By default, this is set to a low value of 4, meaning each data point is an average of 4 readings on the sensor. The other options available are “None,” “Medium,” and “High.” None allows the highest sampling rate with no smoothing (1 reading for every point), while medium and high offer smoother and the smoothest signals, respectively. The drawback to higher levels of noise reduction is that the maximum sample rate frequency will be reduced.
3. **Transmit Rate** – the data rate at which the receiver will talk to the transmitter. Most BLE compatible computers will only support the 1 Mbps option. However, if the users’ computer uses a newer BLE chip, it may be able to use the 2 Mbps option. If 2 Mbps is chosen and the computer does not support it, the system will fall back to the 1 Mbps option. Please note that using 2 Mbps requires closer distances between the transmitter and tablet/receiver. After the first reading, additional information about the sensor will be accessible.
4. **Settle Time** – the settle time of a transmitter should be set minimally to the settle time of the sensor. Settle time can be configured to wait for up to 2.55 seconds after applying power to a sensor to take a reading, which is necessary because all sensors take a brief amount of time before the signal is flat after being turned-on/powering.
5. **Model Number** – The model number of the transmitter.
 Hardware Revision: The hardware revision of the transmitter board.
 Firmware Revision: The firmware revision on the transmitter board.
 Software Revision: The software revision on the transmitter board. (Not the reader software)

Back on the Transmitters window, we will look more in-depth at a sensor indicator. Please see some additional options, as illustrated below.



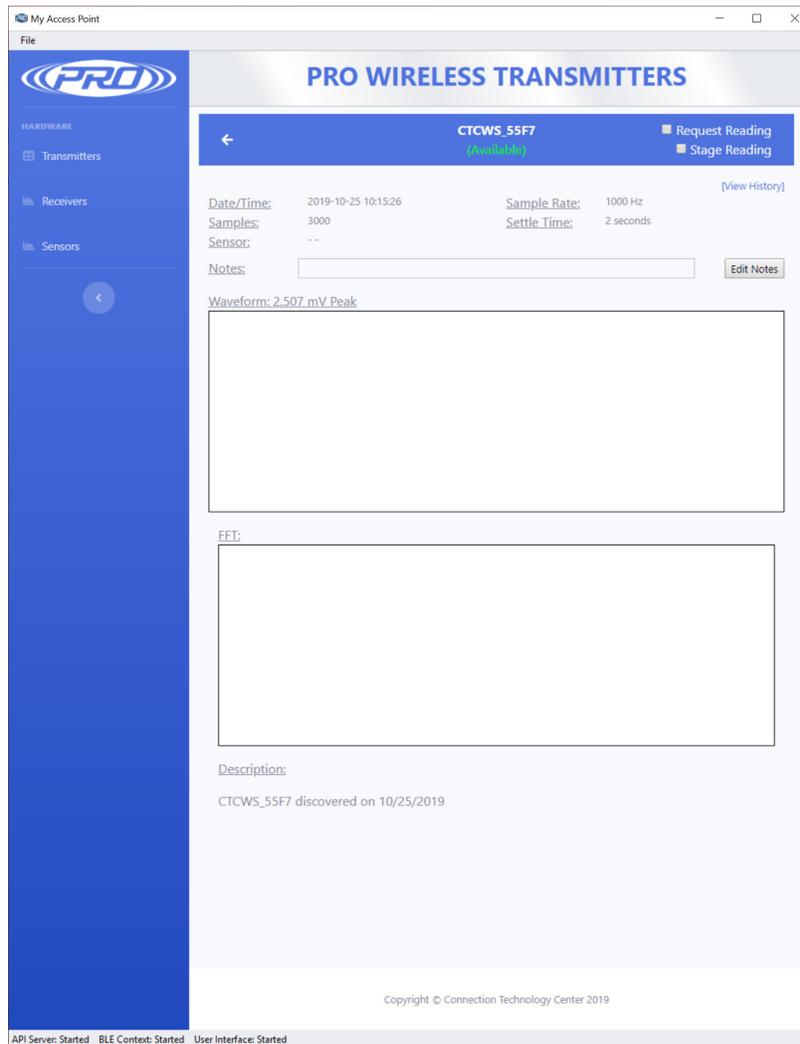
1. **The device name** - this can be changed in the device settings. When a sensor is first discovered, it sets to the ID of the transmitter.
2. **The battery indicator** - displays either Battery OK when a sensor is running with good power or Battery Low when a sensor needs to be replaced.

- 3. The sensor's description** - this is also configurable through the device settings. When a sensor is first discovered, this field is set to the ID of the transmitter. For identification purposes on this screen, it's good to keep either Name or Description as the transmitter ID. It is recommended to leave the name as the ID and use the description as the user identifier.
- 4. The "Edit" button** - brings up the Edit Device screen, as seen in the previous example.
- 5. The sensor's status indicator** - if you are in the vicinity of the sensor and are not taking a reading, this will display Available. It can also show a series of other statuses, like Connecting, Connected, Ready, Requesting, Receiving, or Done, based on the current operation. Lastly, if the sensor is not in the vicinity, dead, or not available, the status will display Offline.
- 6. Delete and Hide options** - Delete erases the sensor and all of its readings from the database, while Hide removes the sensor from view.
 - a.** If you choose to delete a sensor, and it is not truly gone (dead or out of range), it will reappear once discovered again.
 - b.** Deleting a sensor erases all of its associated readings, so please practice caution when deciding to delete a sensor.
 - c.** If you simply don't want to see a sensor, sometimes it is better to hide it, as this removes it from view.
 - d.** Instead of hiding, another option for removing a sensor from view is to put it in a group. Best practice would be to logically group all sensors based on some shared detail like location or use.
- 7.** In the window containing all of the sensors, there is an option that says "Show Hidden Sensors." Checking this box shows all previously hidden sensors, allowing the user to unhide, or perform any other set of actions on said sensors.

Clicking anywhere else on the sensor indicator box other than the Edit, Hide or Delete links, opens the sensors reading pane.



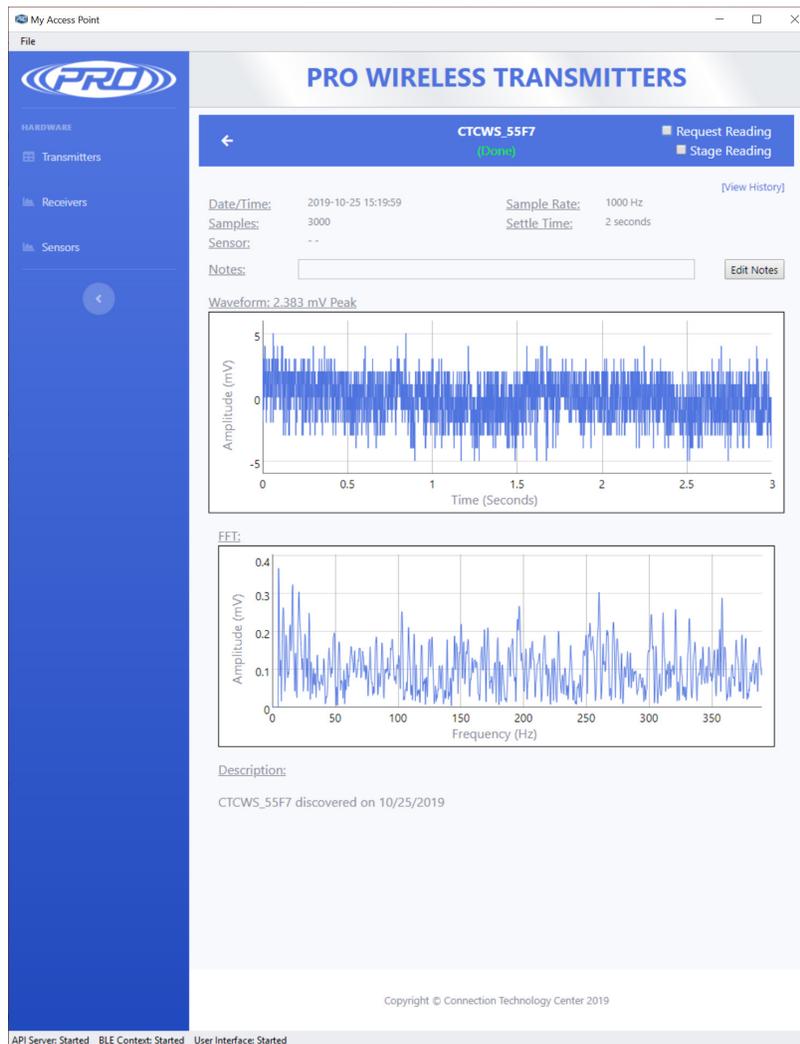
At first, this pane shows no data, as illustrated below.



Check the “Request Reading” checkbox, to initiate a reading.

After checking this box, the sensor will cycle through the other statuses: Connecting, Connected, Ready, Requesting, Receiving, or Done, until a successful reading is taken. If there a weak signal or latency, the sensor may connect and disconnect several times before completing a successful reading.

Once a reading has been taken, the output is displayed in the Waveform and FFT graphs.



Click the edit notes button to keep any relevant notes about the readings for later review. The View History link displays all previous readings from that sensor.

The other option on this screen is the Stage Reading option. Stage reading is similar to the request reading option; however, it does not automatically initiate a reading. As the label implies, it merely "stages" or puts the sensor in a state where a reading can be immediately requested. Staging is useful for scenarios where the user has to initiate a reading without delay. For example, the startup of a piece of equipment or any other timing-sensitive event, where waiting for the sensor to initialize will cause said event to be missed.

It is important to note that staging a sensor is the most intensive operation for battery usage. It is recommended to use this feature sparingly, and utilize Request Reading whenever possible.

Please note: in the previous example, a sensor has not been selected. As a result of no sensor being selected, the output is displayed in 'mV's and not 'g's. Creating a sensor is described in the next section.



Lastly, clicking the back button opens the primary sensor screen.

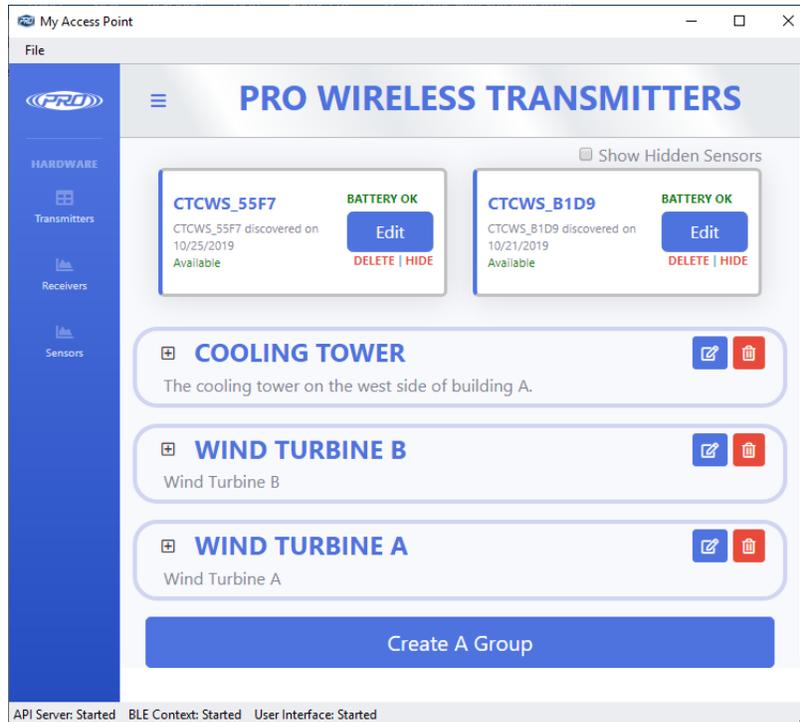
Cleaning Up Readings

The WA102 transmitter is intended for use with 100 mV/g accelerometers. If attached to an accelerometer with a higher or lower response frequency, it might display erratic readings. Due to this possibility, the CTC Wireless application includes noise reduction functionality to help filter out junk data. For information on how to apply these filters, please refer to the Noise Reduction table on page 34.



On the left-hand side of the screen, please notice two other sections.

1. Receivers
2. Sensors



Taking Multiple Readings

Use the following procedure to take multiple readings simultaneously.

1. Stage multiple sensors.



2. Click the Take Reading button on the last sensor.



3. All staged sensors will provide a reading at the same time.



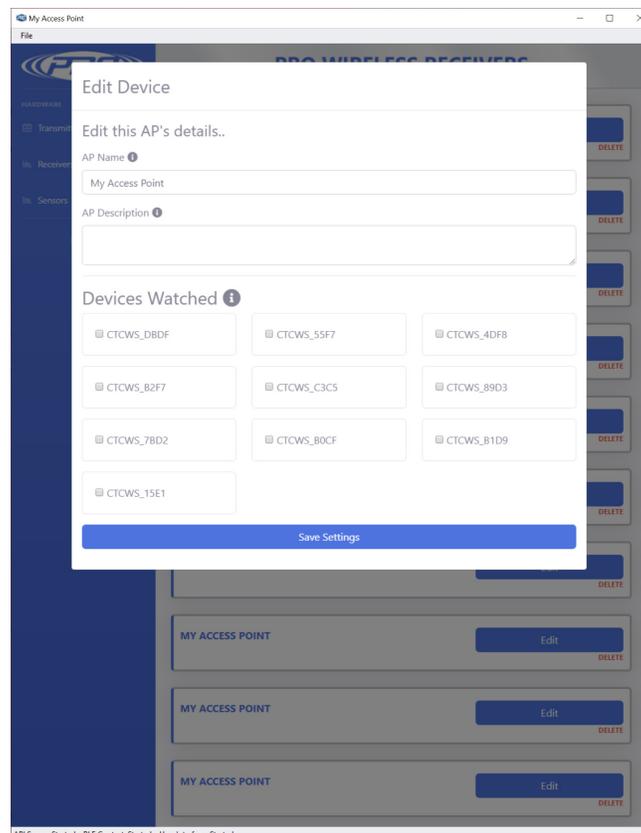
Receivers

This section holds a distinct record for each receiving device that has registered/synchronized with the server.

A receiver can be a couple of things.

1. First, a receiver may be a program just like the one you are using. This program can act as a receiver, a server, a user interface, or any combination of those devices. By default, the program operates as all three options at once.
2. Second, a receiver can be command-line based. It can be a scheduled task that opens a command-line version of the receiver program. This utility and its configuration options are described later in this document.
3. Third, a receiver can be a dedicated computer that sits within the vicinity of a series of sensors/transmitters to take on-demand or scheduled readings. For example, a small Linux powered computer that takes readings and forwards them on to a server.

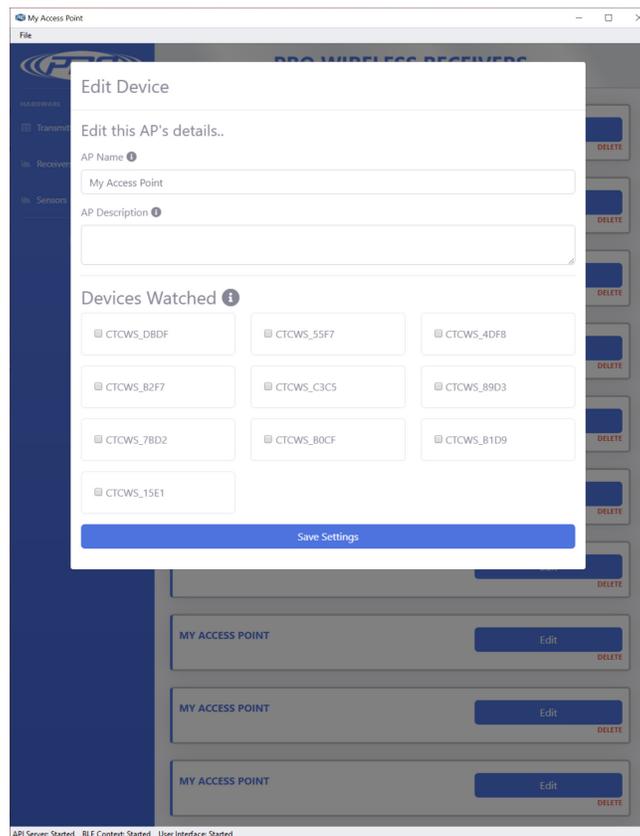
In the example below, the receiver is the application itself, and has automatically assumed the name "My Access Point."



Like the sensors section, the receivers allow the user to fill in and save information to make them distinct and provide some specific operational data. Please note that receiver names are stored on the receivers, so overwriting the name in the form shown below has no effect. The receiver name needs to be maintained on each device or implementation.

There is a section in the example below that shows all of the “Devices Watched.” The screen shows several transmitters that have been discovered by the receiver. Each has an empty checkbox to the left of the transmitter name. When a receiver is configured to watch a particular transmitter (or transmitters), no other receiver will be able to connect to that transmitter(s), unless that other receiver is also configured to watch that transmitter(s) as well. Alternatively, if no receivers are watching a particular transmitter, any receiver within range will be allowed to connect and take a reading.

This feature is useful when partitioning specific receivers to watch specific transmitters. It may be done to reduce latency, or logically keep particular groups of equipment separate from others within the sensor network.



Sensors

This section is useful for setting up and providing essential details about the actual transmitters purchased from CTC. The important details that may be recorded about a sensor include model number, description, serial number, and sensitivity.

The first three fields are self-explanatory:

- Model, the sensor model number
- Description, to record any other relevant information
- Serial, the serial number of the sensor being used

Last is Sensitivity, the fourth field. This field is used to convert readings from 'mV' to 'g' or 'IPS' values, back on the transmitter pane. The sensitivity field is also dynamic. The user can always come back and make small adjustments to the sensitivity, which will instantaneously and retroactively affect any readings done with the connected sensor. This process is useful for custom scaling of the output, so the user can pseudo calibrate a sensor with a known vibration level.

The screenshot shows a web application window titled "My Access Point". On the left is a dark blue sidebar with the "PRO" logo and a menu with "Sensors" selected. The main content area is a white modal box titled "Edit Sensor" with the subtitle "Edit this Sensor's details..". It contains four input fields: "Sensor Model Number" with the value "AC312-1A", "Sensor Description" with "Low Voltage Accelerometer", "Serial Number" with "1234", and "Sensitivity" with "25 mV/g". Each field has an information icon. A blue "Save Settings" button is at the bottom. The footer of the modal says "Copyright © Connection Technology Center 2019". At the very bottom of the window, a status bar reads "API Server: Started BLE Context: Started User Interface: Started".

Under Default Sensor, enter the desired sensor to take readings. Enter the sensitivity that came with the calibration certificate of the sensor. The above example uses an AC312-1A sensor, which will have a 25 mV/g sensitivity.



When entering the sensitivity, be sure to use the following format:

"{Numeric Value} mV/{Unit Of Sensor Output}" (i.e. "25 mV/g").

The blank space between the number and the measurement unit is essential. It ensures that the program can parse the data correctly in the readings window.

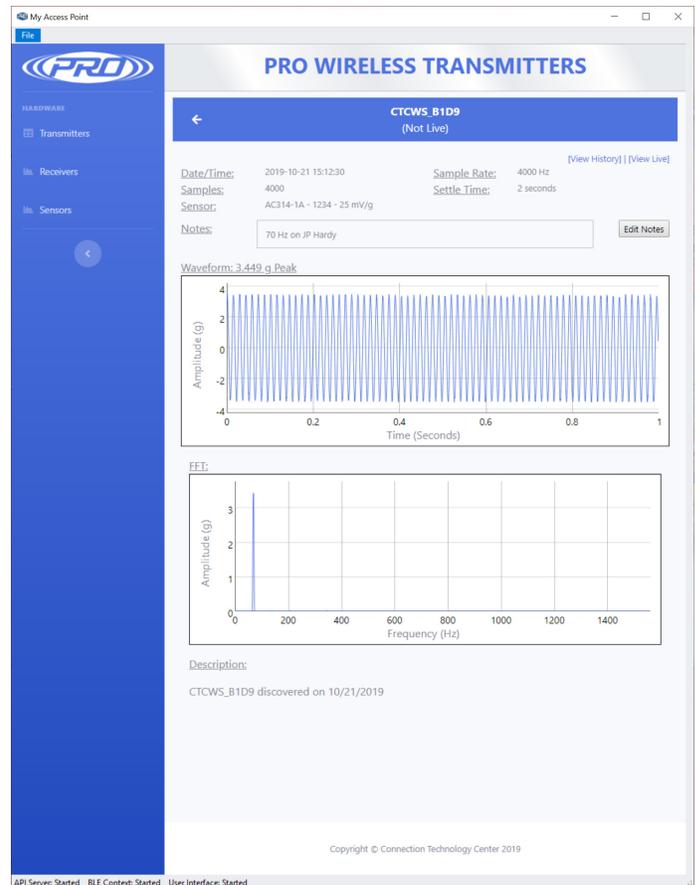
Click Save.

In the transmitters section, find the transmitter that connects to the created sensor, click the Edit button, choose the sensor, and click Save.

Just as before, click in the sensor indicator to go to the reading pane, and check the "Request Reading" box to take another reading.

This time, once the reading is complete, an output will display that reads 'g's or 'IPS' based on the sensor configuration entered.

Please note that if a sample rate is too low, the amplitude may be artificially low or high, as low sample rates diminish amplitude accuracy. Although the Nyquist formula recommends a minimum sample of 2.56 times the expected maximum frequency, 5 times is recommended for a more accurate amplitude calculation.



It is useful to have an existing knowledge of the vibration level an application produces. Once a useful amplitude calculation is obtained, slight adjustments can be made to sensitivity in the sensors window so that output is an exact match.

The Standalone Reader

The standalone reader is a command-line based application that comes bundled with the CTC Wireless Application. The reader is included to take on-demand and scheduled readings.

The most straightforward script is "CTCWS.BLE.READER.exe -watchall 1 -target CTCWS_58E5" which will automatically engage as watching all transmitters and target the transmitter named CTCWS_58E5. The result is the reader attempting one successful reading (with all default settings) from CTCWS_58E5 and sending the resulting data to the default server (<http://localhost:7939>).

Parameters

Here is a list of all the parameters that are available for the reader program:

watchall

Using the "-watchall 1" argument is recommended for any automatically scheduled reading. This setting overrides any watch limitations imposed by the server. In many cases, the reader cannot connect to a server and will save the output locally until a server is within range. It is not recommended to use this option in continuous mode.

target

The "-target CTCWS_58E5" argument tells the program to automatically take a reading from a device it finds called "CTCWS_58E5". There is no default target, and the use case for not providing this value is when running the reader in "continuous" mode, where the reader is always running and reacting to requests from the server.

server

The "-server <https://localhost:1234>" argument can be used to change the server address which this application uses to communicate. The default configuration uses a value of <http://localhost:7939>, which is the default server if this option is not provided.

folder

The "-folder C:/Scan" argument can be used to change the folder in which the program loads its configuration and saves its temporary outputs. C:\ProgramData\CTC\CTCWS.SCAN is the default if this value is not provided.



apid

The “-apid cc8f1b91-60f4-4e84-b69f-082ebb075ae8” argument can be applied to allow distinct and separate records for each of the readers. All readers assume a default value of “0DEFA170-DEFA-DEFA-DEFA-DEFA17DEFA17” if this value is not provided.

savelocal

“-savelocal 1” This argument allows the user to save local copies of the readings for other purposes like consumption by a different program/software. The default is 0 and will only save pending files, which will then be deleted when the server is available to collect them.

justpending

“-justpending 1” The reader can be run with this argument to only upload any pending readings, and not attempt a new reading. The application does this every time, and the default of 0 will run the program normally where it tries to upload any pending files first, then runs the data collection.

c9502

“-c9502 010000000A0D0202FFC80000” allows the user to enter a custom configuration. Please see the next section on how to calculate a 9502-configuration hex value. The default is either the last configuration fetched from the server for this device or a software default if the server configuration is not available and has never been fetched.

c9501

“-c9501 00000BB8” allows the user to enter a custom number of samples to be taken. Please see the next section on how to calculate a 9501-configuration hex value. The default is either the last configuration fetched from the server for this device or a software default if the server configuration is not available and was never retrieved.

continuous

“-continuous 1” places the reader into “continuous” mode. This setting prevents a timeout of the application, and it will run forever. Such a configuration is useful when operating a device as a permanent reader. This program can run in the background or minimized, and react to any server requests for readings. When the reader is not in “continuous” mode, the default timeout is 4 minutes. If there are no successful readings within 4 minutes, the application will automatically exit.



Use Cases

Navigate to the application install directory to find some examples which illustrate two use case scenarios.

"C:\Program Files (x86)\CTC Wireless Application\cmd"

Use Case 1

"usecase1.bat" - The scheduled reading – This example is intended to be set up in the windows scheduler. Running the batch file once attempts a reading, as described at the beginning of this section. It will be helpful to have previously run the GUI at least once and connected to the server you are using, as all settings will otherwise be the default. Using the GUI interface allows you to adjust the reading setting, which is saved to a local file. If the server is unavailable when the scheduled task executes a reading, the local file will serve as a reference to the desired settings, and the reading will perform as intended.

For an introduction on how to use the Windows task scheduler, look at this article from Experts Exchange: <https://www.experts-exchange.com/videos/1598/How-to-use-the-Windows-Task-Scheduler-An-Introduction.html>.

Use Case 2

"usecase2.bat" – The standalone reader – This example uses all the defaults in the previous case, but remains open continuously. It is best practice to schedule this batch file to exist on a schedule that runs every minute and bypasses the next run if the program is already running. This way, if something happens and the program closes or crashes, it can always wakeup again with the next scheduled run. In this example, you would run a server and configure this program to connect to it. The use case uses the default server of <http://localhost:7939/>.

An important feature prevents the program from staying open while in continuous mode. This feature is to close the application if the timeout has passed, and there is no server connection available. If the scheduled task has been set according to the previous paragraph, the program will exit after the 4-minute timeout has expired, and launch another instance at the next scheduled run. Each new instance attempts a fresh connection to the server. This feature prevents an inactive reader in the event a server connection was lost.

Use Case 3: An uploader

"usecase3.bat" – A simple program that you could run every couple of minutes to upload any pending readings.



Calculating 9501 or 9502 Configuration Hex Values

Please see the tables below for the configuration of each of the bytes strings that represent 9501 and 9502.

| SERVICE - CONFIG - 0x9500 | | | | |
|---------------------------|-----------------|-----------------|------------------|-----------------------|
| CHAR NAME | SAMPLES* | CONFIG | MEM_SIZE† | STATUS |
| UUID | 0x9501 | 0x9502 | 0x9503 | 0x9504 |
| ATTRIBUTES | R/W | R/W | R | R/W/N |
| BYTE1 | SAMPLES 31...24 | FREQ | MEM_SIZE 31...24 | MODE_SET |
| BYTE2 | SAMPLES 23...16 | SLEEP 31...24 | MEM_SIZE 15...8 | MISSED_PACKET 31...24 |
| BYTE3 | SAMPLES 15...8 | SLEEP 23...16 | MEM_SIZE 7...0 | MISSED_PACKET 23...16 |
| BYTE4 | SAMPLES 7...0 | SLEEP 15...8 | | MISSED_PACKET 15...8 |
| BYTE5 | | SLEEP 7...0 | | MISSED_PACKET 7...0 |
| BYTE6 | | TX PWR | | |
| BYTE7 | | TX RATE | | |
| BYTE8 | | NOISE_REDUCTION | | |
| BYTE9 | | 255 | | |
| BYTE10 | | SENSOR_SETTLE | | |
| BYTE11 | | CAL_TIME | | |
| BYTE12 | | CAL_VAL | | |

* This is how many samples the sensor will take at the configured frequency. Writing to this characteristic starts the reading. If Bytes1-Bytes4 are 0 the unit will go back to sleep.

† This is the buffer memory size in samples.

How to Interpret the Status Column

Status to Sensor

- 0 Don't Change
- 1 Go to sleep for "SLEEP" seconds
- 2 Go to shipping mode
- 3 Retransmit Missed Packet
- 4 Retransmit Last Reading
- 5 Prepair Sensor for Reading
- 6 Send Battery Voltage

Status from Sensor

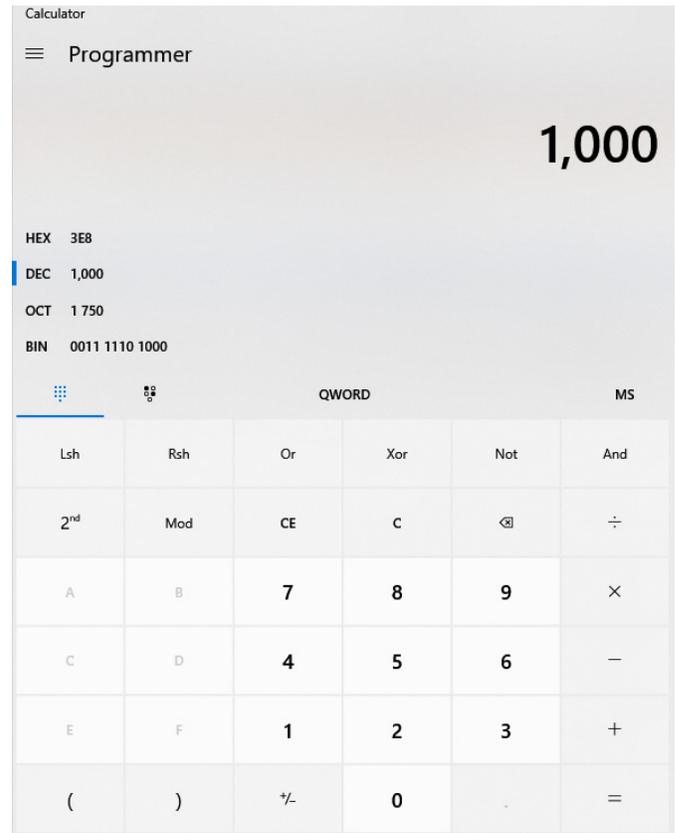
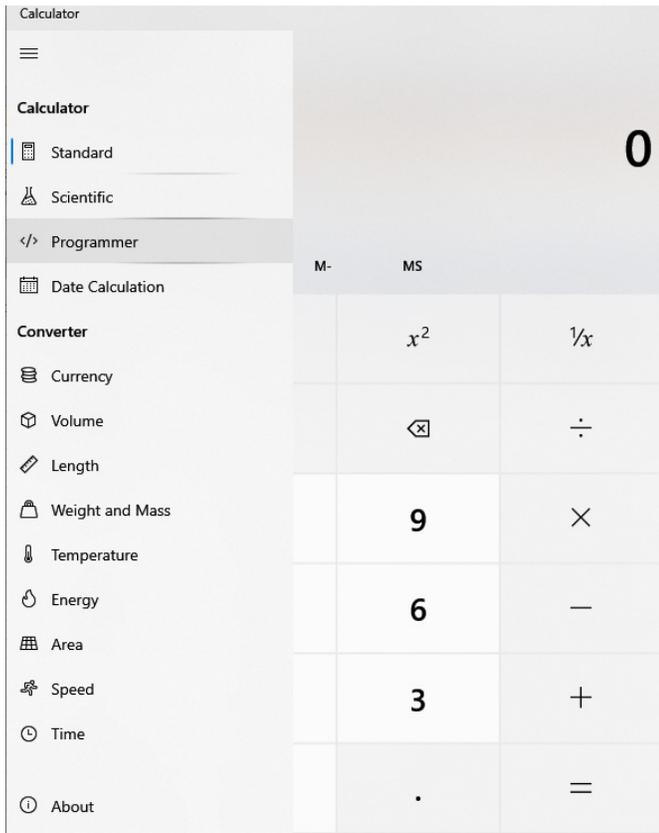
- 100 Transfer Done
- 101 Sensor Ready for Reading (staged mode)
- 102 Battery level in mV
- 150 ERROR: Conversion Still in Process
- 151 ERROR: Incompatible Noise Reduction
- 152 ERROR: Too Many Samples Requested
- 153 ERROR: Frequency Too High
- 154 ERROR: TX Rate Invalid
- 155 ERROR: TX Power Invalid



| SERVICE - DATA - 0x9600 | | | |
|------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| CHAR NAME | DATA | | |
| UUID | 0x9601 | | |
| ATTRIBUTE | R/N | | |
| BYTE1 | PACKET_NUM 23...16 | BYTE11 | SAMPLE4 15...8 |
| BYTE2 | PACKET_NUM 15...8 | BYTE12 | SAMPLE4 7...0 |
| BYTE3 | PACKET_NUM 7...0 | BYTE13 | SAMPLE5 15...8 |
| BYTE4 | CHECKSUM | BYTE14 | SAMPLE5 7...0 |
| BYTE5 | SAMPLE1 15...8 | BYTE15 | SAMPLE6 15...8 |
| BYTE6 | SAMPLE1 7...0 | BYTE16 | SAMPLE6 7...0 |
| BYTE7 | SAMPLE2 15...8 | BYTE17 | SAMPLE7 15...8 |
| BYTE8 | SAMPLE2 7...0 | BYTE18 | SAMPLE7 7...0 |
| BYTE9 | SAMPLE3 15...8 | BYTE19 | SAMPLE8 15...8 |
| BYTE10 | SAMPLE3 7...0 | BYTE20 | SAMPLE8 7...0 |
| <i>Checksum is the lowest byte of the sum of all bytes.</i> | | | |
| <i>Samples need to be multiplied by 3600 then divided by 4096 to get mV.</i> | | <i>Packet Length is dynmaic from 20 bytes(8 samples) to 247 bytes(121 samples). If data packet has an odd number of bytes, the last one will be disregarded.</i> | |



Open the computer calculator app, and navigate to the programmer section.



Once there, type the value to convert (i.e., 1000). The text next to the label for "HEX" will display something like "3EB." Take this value and pad '0' on to the left until the text's length is eight characters (i.e., 000003EB). That will become the value for the c9501 argument (i.e. "-c9501 000003EB").

9502

9502 is a bit trickier in that there are several variables bundled into this byte string. See the table from the beginning of this section for reference.

Byte 1 is the sample rate: use the calculator to calculate the hex string for a value between 1 and 40. A value of 1 (01 in hex) represents 1 kHz, and a value of 42 (2A in hex) represents 40 kHz. If the output is less than two characters, pad the left with '0' until the length is two characters.

Byte 2 – 5 is the device sleep time; this is the amount of time the device will "turn off" in-between advertising cycles. The default in our software is 10 seconds, but this value can be set anywhere from seconds to years. **Warning:** Misuse of this field will result in a sensor that virtually never returns from sleep.



Byte 6 is the transmit power. Use this table to determine what your value should be:

| <u>TX PWR VAL</u> | <u>TX PWR</u> | <u>TX PWR VAL</u> | <u>TX PWR</u> |
|-------------------|---------------|-------------------|-----------------|
| 0 | Don't Change | 7 | 2 dBm |
| 1 | -40 dBm | 8 | 3 dBm |
| 2 | -20 dBm | 9 | 4 dBm |
| 3 | -16 dBm | 10 | 5 dBm |
| 4 | -8 dBm | 11 | 6 dBm |
| 5 | -4 dBm | 12 | 7 dBm |
| 6 | 0 dBm | 13 | 8 dBm *default* |

Use the calculator to calculate the hex string for a value between 1 and 13. A value of 1 (01 in hex) represents -40 dBm, and a value of 13 (2A in hex) represents 8 dBm. If the output is less than two characters, pad the left with '0' until the length is two characters. Additionally, 00 can be used to use the last value entered.

Byte 7 refers to the transfer rate. Use the table below to determine the appropriate value.

| <u>TX RATE Val</u> | <u>TX Rate</u> |
|--------------------|------------------|
| 0 | Don't Change |
| 1 | 2 Mbps |
| 2 | 1 Mbps *default* |
| 3 | 125 kbps coded |
| 4 | auto |

Note: 125 kbps will not work with most devices

Byte 8 is noise reduction, use this table to determine the appropriate value.

| <u>NOISE_REDUCTION VAL</u> | <u>LEVEL</u> |
|----------------------------|--------------------------------|
| 0 | Don't Change |
| 1 | Off |
| 2 | Low (Oversample = 4) *default* |
| 3 | Medium (Oversample = 8) |
| 4 | High (Oversample = 16) |

Note: Low requires sample rate less than 48 kHz
 Medium requires sample rate less than 24 kHz
 High requires sample rate less than 12 kHz

Use the calculator to calculate the hex string for a value between 1 and 4. A value of 1 (01 in hex) represents no noise reduction, and a value of 4 (04 in hex) represents high noise reduction. Make sure if the output is less than two characters, pad the left with '0' until the length is two characters. Also, 00 can be used to use the last value entered.



Byte 9 is advertising timeout, use this table to determine your value.

Use the calculator to calculate the hex string for a value between 1 and 4. A value of 1 (01 in hex) represents an Advertising Timeout of 10 seconds, and a value of 255 (FF in hex) represents no timeout. If the output is less than two characters, pad the left with '0' until the length is two characters. Additionally, 00 can be used to use the last value entered.

Byte 10 is the sensor settle time. For this byte, choose a value between 01 and 255. A value of 1 (01 in hex) means .01 second and 255 (FF in hex) implies 2.55 seconds.

Bytes 11 and 12 are in place for calibration factors that will be rolled out in a future update. By default, this value should be four zeroes (0000).

Finally, take all the values calculated for each byte and string them together like this:

0F + 0000000A + 0D + 00 + 02 + FF + FF = 0F0000000A0D0002FFFF0000

Double check that the length of the string is 24 characters long; if not, go back and recalculate the values.

Warning: Entering invalid data could put the sensor into an irretrievable state, so be sure to triple-check any calculations.



Reader Output

The basic structure of the reader's output is as follows:

{time} - {name}{channel} - [connection status] - [request status] -[status note]

Interpreting a single line of output:

{time} – The time of the current diagnostic

{name} – The assigned name of the sensor, maximum ten characters

{channel} – The diagnostic output channel

[Connection status] - {Available}{Connecting}{Connected}{Ready}

| Output | Definition |
|--------|-------------------------------------------------|
| 1000 | The reader has located the sensor |
| 1100 | The reader is attempting a connection |
| 1110 | The reader successfully connected to the sensor |
| 1011 | The sensor is available to take a reading |

Note: 1011 will display for each stage of a reading. Refer to the status note to determine the individual stage of the reading.

[request status] – {Watched}{Staged}{Requested}

| Output | Definition |
|--------|------------|
| 100 | Watched |
| 110 | Staged |
| 101 | Requested |

Below are some sample status outputs that will display when the reader is running:

14:39:47 - CTCWS_58E51 - 1000 - 100 – Available

14:39:47 - CTCWS_58E51 - 1100 - 101 – Connecting

14:39:52 - CTCWS_58E51 - 1110 - 101 – Connected

14:39:56 - CTCWS_58E51 - 1011 - 101 – Ready

14:39:57 - CTCWS_58E51 - 1011 - 101 – Requesting

14:40:00 - CTCWS_58E51 - 1011 - 101 – Receiving

14:40:01 - CTCWS_58E51 - 1011 - 101 – Complete



CTC Wireless Project

This next section examines the individual components that comprise the CTC Wireless application, and the programming details needed to incorporate them into an existing system.

CTCWS.BLE.NET

The core application is made up of 3 pieces of software, which features several different configurations. The CTCWS.BLE.NET program functions as a bundled installer for these separate software pieces further explained below:

- *Server* - Simple RESTFUL API with an underlying database
- *Client* - HTML Interface implemented in HTML, CSS, and Javascript
- *Receiver* - Windows 10 / BLE 4.0+ Capable Device that supports UWP

The default configuration is to run an embedded API server, which is described by the server section of this guide. The other parts of the default configuration are running an embedded copy of the reader app, and the interface described in the interface section of this guide. Refer to these sections for more information about the different parts of this program.

The Wireless Sensor - For Developers

- *Bluetooth® and Configuration Information* - An Excel Document outlining the Bluetooth® Services and Characteristics and acceptable values for each Characteristic.



Server

The server acts as a central repository for all readings, sensor data, and access point data. The client and the reader connect to the server to retrieve and update the sensor, access point and reading information.

Technology Used / Requirements

- .NET Core 2.2 - Compatible with Windows, Mac and Most Linux Platforms
 - Web API - The application uses Web API as the communication mechanism between the server, receiver, and client.
 - REST - Most of the data objects are exposed through a RESTFUL format. However, access to the core RESTAPI has been disabled for security purposes; the functions critical to the operation of this application are available through a supplemental implementation.
 - SignalR - A socket-like communication framework that servers can use to communicate with HTML/Javascript front ends.
 - Dapper - Dapper has been used as an alternative to the Entity Framework. Dapper provides excellent raw execution performance with minimal overheads and allows the user to retain control over the SQL.
 - JSON - JSON is the default technology for Web API, and has been selected for this project, being more lightweight and less strict than XML.
- Microsoft SQL Server 2012 or Above - While this application should work with any MSSQL2012+, SQL Express was used to develop the current CTC Wireless Application. SQL Express is a free, world-class database provided as an entry-level offering to their paid enterprise SQL server platform. It is an excellent choice for a small database like this, which gives the implementer room to grow should they someday (or already) want to use the enterprise version. SQL Express can run on Windows, Linux, and Docker.
- Other Databases - Since the server application is the only entry point into the database interaction, we have focused on our implementation to run on MSSQL. However, it would be a relatively easy modification to communicate with other database platforms such as MySQL, SQL Lite, or Oracle.



Data Structures

Primary Data Structures

```
/// <summary>
/// A BLE device
/// </summary>

public class Device

{
    public Guid? id { get; set; }
    public string name { get; set; }
    public string description { get; set; }
    public string notes { get; set; }
    public string addr { get; set; }
    public int? samples { get; set; }
    public int? frequency { get; set; }
    public int? sleeptime { get; set; }
    public int? txpower { get; set; }
    public int? txrate { get; set; }
    public int? noised { get; set; }
    public int? advtimeout { get; set; }
    public int? centralwait { get; set; }
    public string master { get; set; }
    public string sleeptimeuom { get; set; }
    public string advtimeoutuom { get; set; }
    public string centralwaituom { get; set; }
    public int? settle { get; set; }
    public string stat { get; set; }
    public string dt { get; set; }
    public bool? stage { get; set; }
    public int? battery { get; set; }
    public bool? request { get; set; }
    public bool? hidden { get; set; }
    public Guid? sensor { get; set; }
    public Guid? devicegrp { get; set; }
}

/// <summary>
/// A BLE device reading
/// </summary>
```

```
public class Reading
{
    public Guid? id { get; set; }
    public string dt { get; set; }
    public string addr { get; set; }
    public int? samples { get; set; }
    public int? frequency { get; set; }
    public int? noised { get; set; }
    public string points { get; set; }
    public int? settle { get; set; }
    public string notes { get; set; }
    public Guid? device { get; set; }
    public Guid? sensor { get; set; }
}

/// <summary>
/// A BLE Access Point
/// </summary>

public class Accesspoint
{
    public Guid? id { get; set; }
    public string name { get; set; }
    public string description { get; set; }
    public string dt { get; set; }
    public string addr { get; set; }
    public string devices { get; set; }
}

/// <summary>
/// A Physical Sensor Readings are taken from (I.E. AC314-1A)
/// </summary>

public class Sensor
{
    public Guid? id { get; set; }
    public string name { get; set; }
    public string description { get; set; }
    public string serial { get; set; }
    public string sensitivity { get; set; }
}
```

```
/// <summary>
/// A Grouping of Devices
/// </summary>

public class Devgroup

{
    public Guid? id { get; set; }
    public string name { get; set; }
    public string description { get; set; }
}
```

Shared Data Structures

```
/// <summary>
/// Copy and paste of the classes that are in CTCWS
/// </summary>

public class SlimBluetoothLEDevice

{
    public ulong BluetoothAddressAsUlong { get; set; }
    public string SamplesPerSecond { get; set; } = "1";
    public string SamplesToTake { get; set; } = "1000";
    public string TimeToSleep { get; set; } = "60";
    public string TransmitPower { get; set; } = "13";
    public string TransmitRate { get; set; } = "2";
    public string NoiseReduction { get; set; } = "2";

    public string AdvertisementTimeout { get; set; } = "30";
    public string TimeToWait { get; set; } = "120";

    public string DeviceName { get; set; } = "No Name";
    public string DeviceDescription { get; set; } = "";
    public string DeviceNotes { get; set; } = "";
    public bool DeviceMaster { get; set; } = false;

    public string TimeToSleepUOM { get; set; } = "S";
    public string TimeToWaitUOM { get; set; } = "S";
    public string AdvertisementTimeoutUOM { get; set; } = "S";
    public string Settle { get; set; } = "200";
    public bool Stage { get; set; } = false;
    public bool Request { get; set; } = false;
}
```

```

/// <summary>
/// The data contained within a reading
/// </summary>

public class WSReading

{
    public DateTime dt { get; set; }
    public SlimBluetoothLEDevice dev { get; set; }
    public Dictionary<int, WSPacket> Packets { get; set; } = new Dictionary<int, WSPacket>();
    public string Notes { get; set; } = "";
}

/// <summary>
/// A single packet of data within a reading
/// </summary>

public class WSPacket

{
    public int Num { get; set; }
    public bool Waiting { get; set; }
    public List<int> Points { get; set; } = new List<int>();
}

```

Interface/Client Data Structures

```

/// <summary>
/// A collection of the reading and fft
/// </summary>

public class WaveData

{
    public bool setStageFalse = false;
    public Conn.Reading reading { get; set; }
    public string fft { get; set; }
}

/// <summary>
/// A simple version of the reading for the search results
/// </summary>

public class SimpleReading

```

```
{
    public Guid id { get; set; }
    public string notes { get; set; }
    public string dt { get; set; }
}

/// <summary>
/// an object to do a partial update on the status of an object
/// </summary>

public class StatUpdate

{
    public ulong BluetoothAddressAsUlong { get; set; }
    public string Status { get; set; }
    public int Battery { get; set; }
}
```

Tertiary Data Structures

```
/// <summary>
/// A Generic SearchResult
/// </summary>
/// <typeparam name="T"></typeparam>

public class SearchResult<T>

{
    public int ct { get; set; }
    public T obj { get; set; }
}

/// <summary>
/// A Count Object
/// </summary>

public class Count

{
    public int ct { get; set; }
}
```

Application Flow

There is no real flow to the server component of this application, as each endpoint represents a stateless action to the interface. Listed below are the parameters the GUI and Receiver portions of the application use.

Device Methods

- url: api/Device, method: GET
 - This endpoint returns all sensors that have been added to the database.
- url: api/DeviceImpl2, method: GET
 - This endpoint returns all sensors that have been added to the database in the SlimBluetoothLEDevice format used by the reader application.
- url: api/DeviceImpl2, method: POST
 - This endpoint updates the staged status of a sensor.
 - It expects a Device object to be passed as JSON in the body of the request.
- url: api/DeviceImpl2, method: POST
 - This endpoint receives a reading, appends it to the database, and creates the device if it doesn't already exist. It also creates FFT and WAV files.
 - It expects a WSReading object to be passed as JSON in the body of the request.
- url: api/Device/{Device ID}, method: PUT
 - This endpoint updates the reading settings of a sensor.
 - {Device ID} should be the valid GUID of a sensor.
 - It expects a Device object to be passed as JSON in the body of the request.
- method: DELETE, url: api/DeviceImpl2/{Device ID}
 - This endpoint deletes a sensor and all of its readings from the database.
 - {Device ID} should be the valid GUID of a sensor.

Access Point Methods

- method: GET, url: api/Accesspoint
 - This endpoint will return all the access points that have been added to the database.
- method: GET, url: /api/AccesspointImpl2?id={Access Point ID}
 - Gets the information for a single access point.
 - {Access Point ID} should be the valid GUID of an access point.



- method: PUT, url: api/Accesspoint/{Access Point ID}
 - This endpoint updates the settings of a specific access point.
 - {Access Point ID} should be the valid GUID of an access point.
 - It expects an Access Point object to be passed as JSON in the body of the request.
- method: DELETE, url: api/AccesspointImpl2/{Access Point ID}
 - This endpoint deletes a specific access point from the database.
 - {Access Point ID} should be the valid GUID of an access point.

Reading Methods

- method: PUT, url: api/ReadingImpl2/{offset}/{limit}
 - This endpoint allows a partial set of data to be returned. Use it for paging data.
 - It expects a Reading Guide to be passed as JSON in the body of the request.
 - {offset} is where to set the current lookup, while {limit} limits the number of results returned.
 - This method is a PUT because its base implementation allows the PUT of a full reading object for the purpose of searching.
- method: DELETE, url: api/ReadingImpl2/{Reading ID}
 - This endpoint allows for the deletion of a specific reading.
 - {Reading ID} should be the valid GUID of a sensor.
- method: GET, url: api/ReadingImpl2?xid={Device ID}
 - This endpoint gets the very last reading for a specific sensor.
 - {Device ID} should be the valid GUID of a sensor.
- method: GET, url: api/ReadingImpl2/{Reading ID}
 - This endpoint gets a specific reading.
 - {Device ID} should be the valid GUID of a sensor.
- method: PUT, url: api/ReadingImpl2
 - This endpoint allows the notes of a reading to be updated.
 - It expects an Access Point object to be passed as JSON in the body of the request. Only the notes will be allowed to pass through for updates.
- method: POST, url: api/ReadingImpl2
 - This endpoint allows the status of a reading to be updated.
 - It expects an Access Point object to be passed as JSON in the body of the request. Only the status will be allowed to pass through for updates.



Group Methods

- method: "GET", url: api/devgroup"
 - This endpoint will return all the groups that have been added to the database.
- method: = "POST", url: api/devgroup/";
 - This endpoint creates a new group.
 - It expects a Group Object to be passed as JSON in the body of the request.
- method: = "PUT", url: api/devgroup/{Group ID}
 - This endpoint updates the settings of a specific group.
 - {Group ID} should be the valid GUID of a group.
 - It expects a Group Object to be passed as JSON in the body of the request.
- method: "DELETE", url: api/devgroup/{Group ID}
 - This endpoint deletes a specific group from the database.
 - {Group ID} should be the valid GUID of a group.

Sensor Methods

- method: "GET", url: api/Sensor"
 - This endpoint will return all the sensors that have been added to the database.
- method: = "POST", url: api/Sensor/";
 - This endpoint creates a new sensor.
 - It expects a Sensor object to be passed as JSON in the body of the request.
- method: = "PUT", url: api/Sensor/{Sensor ID}
 - This endpoint updates the settings of a specific group.
 - {Sensor ID} should be the valid GUID of a sensor.
 - It expects a Sensor Object to be passed as JSON in the body of the request.
- method: "DELETE", url: api/Sensor/{Sensor ID}
 - This endpoint deletes a specific sensor from the database.
 - {Group ID} should be the valid GUID of a sensor.

Common Methods

- method: "PUT", url: api/{Type}/name/{Offset}/{Results Per Page}/1"
 - This method retrieves a paged result of objects of a particular type sorted alphanumerically by its name.
 - {Type} - The type of object being queried (sensor, devgroup, reading, device, accesspoint).



- {Offset} - The paged offset - start at the defined value.
- {Results Per Page} - the number of results to return.

It expects an object of { name: {searchtext}} to be passed as JSON in the body of the request.

Accessing the JSON File

Launch the software, then open a browser and enter <https://localhost:7939> in the address bar. This will load a web version of the software. Press F12 to the browser's inspection tool, and click on the Network tab at the top of the inspection window. Once the Network tab is selected, access a reading, in the browser and the reading address will be displayed in the inspector window. Click on the address of the reading, and then select the Response tab in the window that appears. The JSON data will be displayed here.

Client

The client to the software is a simple single-page web app. It appears as the default page shown by the CTC Wireless Application, or can also be browsed to by pulling up the address of a CTC Wireless Server in a browser window.

Technology Used / Requirements

- CefBrowser - CefBrowser is a Chromium web pane that can be drawn onto any .NET Framework Web Form or Windows XAML Window.
- Angular JS and Bootstrap 4 are common web development frameworks that were used to build the client application.
- FontAwesome - is used for icons and symbols.
- SignalR - is used for socket-like communication with the server.

Data Structures

Except for the shared data structures, the client application uses the same data structures as the server. Please review the server section to understand which data objects are being passed between the server and the client.

Application Flow

There are four entry points into the application, which are represented by four URL formats used by the angulars routing engine.

```
$routeProvider
// The default view - devices and groupings
.when("/", {
  templateUrl: "views/main.html"
})

// The device view - defaults to current reading data
.when("/sen/:devid", {
  templateUrl: "views/red.html",
})

// The Reciever/AP view - see all recievers and APs
.when("/aps/", {
  templateUrl: "views/apmain.html",
})
```

```
// looking at one ap - not implemented

.when("/aps/:apid", {
  templateUrl: "views/apred.html",
})

// The Sensor view - see all sensors

.when("/sensor/", {
  templateUrl: "views/sensormain.html",
})

// looking at one sensor - not implemented

.when("/sensor/:sensorid", {
  templateUrl: "views/sensorred.html",
});
```

Initialization

The application behaves like any other Angular JS application and is kicked off by the ng-init directive.

```
<div id="content" ng-app="ctcws.app" ng-controller="AppCtrl" ng-init="initialize()">
```

The initialize function does the following:

- Starts up a SignalR Connection with the server.
- Sets an interval to refresh the data on the page.
- Initializes all the fields and their defaults.
- Refreshes the data - As long as there is nothing in process, the refresh fetches the following data.
 - All Devices
 - All Access Points
 - All Sensors
 - All Groups

Main Application

At this point, the application is live, and the rest of the program is based on events that come from the server, the automatic refreshes, or user actions.



The user can choose to change:

- Devices: (Edit, Delete, Update, Hide)
 - A reader discovering a new device handles creation.
 - The view feature brings the user to a window where they will see the latest reading.
 - Reading: (Edit Notes, Delete)
The reading pane also has a path to get to the history of readings stored by the database.
- Sensors: (Create, Edit, Delete, Update)
 - Viewing Sensors is not implemented.
- Device Groups: (Create, Edit, Delete, Update)
 - Viewing Device Groups is not implemented.
- Access Points: (Edit, Delete, Update, Hide)
 - Creation is handled by a server being notified by a new reader.
 - Viewing Access Points is not implemented.

All of the classes of objects in the system utilize roughly the same set of functions for CRUD operations, lookup, and searching.

SelectableList Component

The 'selectableList' component is created for the management of objects within the application. It significantly reduces some of the mundane coding required to set up the interfaces for managing individual objects and has been used extensively throughout this application.

```
<selectable-list array="appdata.devices" val="appdata.seldeviceid"
  edit="true" sl-class="col-6" folder="devices"
  filter="{devicegrp: '!}'"
  selectfcn="selectDevice" pre-validationfcn="saveDevice"
  saveselect="false" cancelfcn="canDevice"
  loadfcn="loadDevice" delete="true" delfcn="delDevice"
  other="{timeuom:appdata.timeuom,freqs:appdata.freqs,
  noises:appdata.noises,txpowers:appdata.txpowers,
  settles:appdata.settles,showhidden:appdata.showhidden,
  advtimeouts:appdata.advtimeouts,adtimeoutchg:adtimeoutchg}"
  othfcn1="hideDevice"></selectable-list>
```

The 'selectableList' allows the user to show a collection of an object type and provides access to edit, delete, add, and update functionality by exposing these calls to functions in the appropriate scope. Every 'selectableList' is defined with a folder that points to its list and modal templates; if no folder is assigned, the primary folder is chosen by default. For creating unique templates, its best to make a copy of the primary folder, as much about the way these lists work can be derived from the functionality presented by the basic templates. These template folders can be found in the lists folder.

Within a 'selectableList,' a collection is shown by rendering a set of bootstrap divs; this is managed by a list template that defines how each list will appear and which shared buttons are available. When a user presses the Add or Edit buttons, they are presented with a modal screen, which is driven by a modal template of the 'selectableList' folder. The modal is a form that should have fields that represent the type of object being edited. The modal contains some functionality for validation, and any other utilities common of Angular JS templates.

Typical functions include: Save, Delete, Cancel, Edit/Load, Set, and Select. Pressing the save button invokes a save operation on the main scope. Pressing the delete button on the list invokes a delete operation on the main scope. When a modal opens, a load function is fired that allows for added functionality to be performed before a modal fully loads. A Select function on the list allows for custom functionality on the main scope, which redirects to a new URL governing the object the user has selected. A cancel function exits the modal and does not save changes.

Here is a basic outline of the functions paired with each class of objects needed by the selectable list:

- 1.** `$scope.select{Type} = function (x, y, z)`
 - a.** Happens when the user selects an object. It redirects to the URL that governs that object. The redirection causes the routing change to fire, and the interface will transport the user to the applicable pane on the interface. This is implemented primarily by the device object.
- 2.** `$scope.save{Type} = function (x, cb)`
 - a.** Gives the user a new set of data that can be saved to the database.
- 3.** `$scope.can{Type} = function (x, cb)`
 - a.** Primarily cancels the modal popup.
- 4.** `$scope.load{Type} = function (ob, tx, oth)`
 - a.** Allows the user to edit the data of an object as it is loaded into the modal.



5. `$scope.del{Type} = function (x)`
 - a. Allows the user to handle the delete action of a selectableList object.
6. `$scope.setSel{Type} = function (x, y)`
 - a. The reaction to the change to the route, resulting in an object being selected, and additional functionality being performed.
7. `function set{Type}(x)`
 - a. The actual code that selects the particular object.

The use of 'selectableList' controls much of the front end tasked with managing object properties for this application, and the navigation needed for seeing different views for a given object.

Routing

This application uses the angularjs \$routeProvider to determine which screen the user should be seeing based on the URL they are visiting.

Most importantly, when a user selects a device, the 'selectableList' component invokes the 'selectDevice' function, which redirects our screen to the correct URL that governs that device. The redirection invokes angularjs's \$routeChangeStart event which makes variable adjustments in the program, including filling in the appropriate data object, so the user is transported to the correct window on the interface. As is standard with Angular JS routing, the whole sequence of routing events will also occur if a user navigates to the same URL for a specific device.

SignalR

The initialization sequence starts up a connection to a SignalR server. The SignalR server is used to transmit new readings and status information to users logged into, and watching the live updates on, a specific device.

Readings

When the server receives a reading, it is broken apart into its wav and fft components. Sensitivity information is gathered from the linked sensor, and calculations are performed on the reading and fft to convert its value to g or IPS or another UOM provided by the sensor. If no sensor is linked, the program defaults to display mV. The end arrays of readings and fft data are then sent to the 'drawGraph,' which prints them to the screen using the 'Dygraph' javascript graphing library.



The same functionality applies if a user browses to a historical reading, or when the user first connects to a device which brings up the very last reading. The only difference is that these historical readings are read through WebAPI calls.

Status Updates

As the sensors connect and prepare to take readings, a series of status messages are sent to the SignalR server, which is then logged and also passed back to any users signed into the device, which is broadcasting its status.

Requesting, Staging or Executing a Reading

The final purpose SignalR serves is to send messages when a user checks the Request/Stage check-boxes, or click the Execute Reading button on a staged device. These events send messages to the server, which will be passed onto the reader to signal that something is supposed to happen. The reader reacts by taking said action(s), which results in the initialization of each process that is supposed to occur on the readers.



Receiver/Access Point (Central)

Next to the sensor's actual functioning, the Receiver/Access point software is the most essential piece of functionality for using the CTC Wireless Sensors. Without a receiver, all the user has are RAW Bluetooth® transactions, which would prove difficult, if not impossible, to complete sensor readings.

Technology Used / Requirements

- Bluetooth® 4.0+ BLE Communication
- Windows 10
- UWP - Universal Windows Platform

CTCWS Project

- CTCWS.BLE.LIB (UWP) - The core library that controls and manages the Bluetooth® connections and all of the data that goes with them.
 - Connection level functionality and logic were borrowed from Microsoft's open-source Bluetooth® LE Explorer project.
 - Minimal edits to the original files and inclusion of partial files afford added functionality required by the CTC Wireless Sensor App.
 - All Deviations are labeled mod or modx.
 - The CTC Sensor file represents the core logic specific to the current iteration of the CTC wireless sensor as of Q4-2019. Said functionality would find one of many sensors in the vicinity, connect to them, set any/all reading parameters, and record a reading.
- CTCWS.BLE.NET.LIB - This is a wrapper class for the UWP functionality for ease of use in .NET Framework.
- CTCWS.BLE.READER - This is a bare-bones command-line application that uses the .NET wrapper library to take readings.
- CTCWS.BLE.NET - The GUI part of the project, mainly this serves as a shell to house and start the reader functionality, run or connect to the server, and display web front-end/GUI.

CTCWS.BLE.LIB (UWP), CTCWS.BLE.NET.LIB, CTCWS.BLE.READER

The CTCWS.BLE.LIB project derives from the Microsoft Open Source Project Bluetooth® LE Explorer. Bluetooth® LE Explorer is a generic BLE reader program that can be used to connect to any BLE sensor, browse its information and execute raw Bluetooth® functionality. This core functionality of connecting to sensors, enumerating properties, and setting/getting characteristic data has primarily been reused from Microsoft's



Bluetooth® LE Explorer project. There was enough new functionality specific to the CTC Wireless Transmitter that it derives from the project rather than forks development. As a result, the CTC Wireless App has become a new software development on its own.

The Bluetooth® LE Explorer was MIT licensed by Microsoft, allowing CTC to use the code and make modifications to achieve the desired result. We have used this benefit to create the CTC Wireless App, a program that communicates with a CTC Wireless Transmitter to change configuration settings and ultimately take wireless vibration readings. The files that were reused from the Bluetooth® LE Explorer have been kept as unchanged as possible, keeping the Microsoft copyright intact, and also allowing for the merger of any future development by Microsoft into said files. For more information on Bluetooth® LE Explorer, visit the GitHub page for [Bluetooth® LE Explorer](#). Additionally, the Bluetooth® LE Explorer user application is freely available through the Microsoft Store and can serve as a useful side program to the CTC Wireless App. It was utilized during development for performing diagnostics and debugging CTC Wireless Transmitters outside of the CTC Wireless App.

Examining the Project

Upon opening the CTCWS.BLE.LIB project, the user will notice three main folders (GattHelper, Models, and Services). Everything in the 'GattHelper' and 'Services' folders was directly borrowed from the Bluetooth® LE Explorer project. It also contains utility classes that serve functions useful for data conversion and BLE protocol definitions. These are important to the underlying Bluetooth® communication but do not serve the CTC Wireless Reader with any direct functionality. The Models folder houses the critical functionality for the CTC Wireless Reader. Take note of the file naming convention. Any files that do not end with modx.cs or mod.cs (except CTCSensors.cs) are the core files packaged with Bluetooth® LE Explorer. These are the same files that were in the Bluetooth® LE Explorer project but have had small changes made to get them to work with the rest of the CTC code. Any files labeled modx.cs or mod.cs are modifications to the original program, and finally, the single file named CTCSensors.cs is the core logic for working with a CTC Wireless Sensor. The first part of the name of sets of files is the same. This is because any file with the same first part of its file name belongs to the same C# class. Using C# partial files allowed for this functionality.

Application Flow

CTCWS.BLE.READER and CTCWS.BLE.NET.LIB act as a segway into describing the application flow of the CTCWS.BLE.LIB project. CTCWS.BLE.READER is a straightforward project which collects some command-line arguments and passes them onto a series of properties in the CTCWS.BLE.NET.LIB class called 'NETGattSampleContext.' These



properties control such behavior as which server to connect to, what folder stores output, how to communicate a timeout, and what id/names to use for identification. 'NETGattSampleContext' also exposes a 'load()' function that starts the reader routine, which serves as the primary means of creating and executing an instance of the underlying GattSampleContext class. The instance of 'NETGattSampleContext' represents the receiver as an object to all implementing .NET Framework programs. It also handles all of the communication with the server and file system. Communications include transmitting status updates and readings or storing configurations and pending reading files to the file system. 'NETGattSampleContext' also is a wrapper class to the CTCWS.BLE.LIB(UWP) class 'GattSampleContext,' which holds all the functionality required to communicate with a CTC Wireless Transmitter. The whole reader process is started from the load() function through a call on the GattSampleContext of 'StartEnumeration()'

Flow from within the GattSampleContext

When the 'StartEnumeration()' function begins to run, it uses .NET UWP Bluetooth® functionality to collect advertisements from nearby Bluetooth® devices. It looks closely at each advertisement looking for a device that starts with a prefix of 'CTCWS_'. When it finds these devices, it encapsulates a reference to them in a new instance of its device class called 'ObservableBluetoothLEDevice.' When an ObservableBluetoothLEDevice is created, it also creates and holds onto a reference to an overarching "Work Flow" class that implements the IBLEDevice interface. The new instance is then queued in an array of objects that are available to establish a connection.

A side note on the "class implementing the IBLEDevice interface:" it functions similarly to a "Work Flow" class, which is designed to do all the high-level and implementation-specific communication with a connected device. In the case of this program, it is represented by the CTCSensor class. As mentioned above, this class handles all of the functionality specific to the CTC Wireless Sensor.

Additionally, the 'IBLEDevice interface' has been designed to be independent of the communication protocol (despite its name). The program is built for expansion, allowing the addition of new future implementations of the IBLEDevice interface in order to connect to sensors or protocols that may be implemented in the future.

When an end-user with the CTC Wireless App places a Request or Stage command on a sensor, a field in the database is set, indicating what the user wants to do. On the reader, each time a device advertisement is received, the application requests updated data from the server. When the new data is collected, if the application sees that the user has placed a command, it initiates a connection to that device.



The connection is initiated through the `'_Connect()'` function of the `ObservableBluetoothLEDevice` class. Generally, what the `_Connect()` function does is make sure everything is in the right state for a connection, resetting any other state-specific variables and allowing the user to connect with a fresh start. Next, the actual connection is run by the native `'Connect()'` command (no underscore). The `Connect` command runs a `'GetGattServicesAsync'` on the native `BluetoothLEDevice` object, which collects all BLE services, and creates `'ObservableGattDeviceService'` out of them. This process of enumerating, collecting, and encapsulating continues down to the descriptor level in the BLE structure until the full object is described, and everything is quantified.

Meanwhile, on the `'ObservableBluetoothLEDevice'` class, a previously set up `CharDiscovered` function gets notified for every characteristic that each service finds. This function is waiting for there to be a match to a target characteristic name so that it can be confident that the sensor it is talking to legitimately is a CTC Wireless Sensor. Once this happens, the `IsReady` flag is set to true. Setting the `IsReady` to true invokes the `'SensorInit()'` function of the `CTCSensor(IBLEDevice)`, which initializes the higher-level logic of the `CTCSensor` implementation.

Flow from within CTCSensor

In the `CTCSensor` implementation, the `SensorInit` function call first gets the reading of the four critical characteristics.

```
<code csharp>
    string w = await o.Read(p9501, DisplayTypes.Hex); // The number of samples to read
    string x = await o.Read(p9502, DisplayTypes.Hex); // The configuration of the sensor
    string y = await o.Read(p9503, DisplayTypes.Hex); // The max memory size of the sensor
    read only
    string z = await o.Read(p9504, DisplayTypes.Hex); // The sensor status
</code>
```

By now, the `CTCSensor` object also has a copy of the configuration parameters that the user requested (gathered from the server data). It compiles a hex string of new configuration data for the sensor and compares it to the configuration that was read from the server. If there is a difference, it writes the configuration to the server.

The call also engages notification on the p9601 (Data Received) and the p9504 (Status Changed) characteristics. This occurrence creates a listener. A Bluetooth® characteristic is analogous to a property or a field. Engaging a notification registers change notifications to said characteristics.



After resetting a few additional variables, the program is ready to collect some data. If the user made an ordinary data request, all that happens is a value is written to the 9501 (number of samples to read) characteristic. If the user made a Staged data request, the sensor must be staged by writing a '05'+(number of samples hex) to the 9504(sensor status) characteristic.

```
<code>
    string samples = o.hexFromDec(SamplesToTake, 8);
        //"000007D0"; // 2000 Samples -
        // Watchout the max samples and min sample
        // rate will produce a sensor that samples for 48+ days
        // I dont think the memory will hold this though.
        //await  logData("Requesting Data");
        //string c9501 = samples;
        //var _w = await Write(p9501, c9501);
        // 05 is the command to tell the sensor to go into staging mode
    string mode = "05";
    // Compile the command
    string c9504 = mode + samples;
    // Write the command
    var _z = await o.Write(p9504, c9504);
</code>
```

Doing this should result in receiving a 101 code on the 'StatusChanged()' function. When this is received, the status is updated, which returns to the user, showing an "Execute Reading" button. When the user clicks the button, SignalR sends a command "STAGEGO," which will initiate a reading on any readers connected to a staged sensor.

On the reader, starting a reading is handled by writing the number of "Samples To Take" to the p9501 characteristic. Once this happens, the user begins to receive data packets on the p9601 (Data Received) characteristic. Data is parsed and converted to int values by the DataPacketRcv() function. All of these values are saved to a List in order of reception until no more packets are received. At the same time, the program looks for a 100 command, which indicates that the sensor is finished sending data. At this time, a flag is set indicating that the data is ready for validation.

Once the reader has stopped receiving new data for over .3 seconds and the 'ready to validate' flag is set, validation of the data begins. If some packets are missing, the reader starts a loop to request specific packets and attempt further validation. If more than 49 readings were missed, the reading is declared as failed, and the reader disconnects from the sensor.



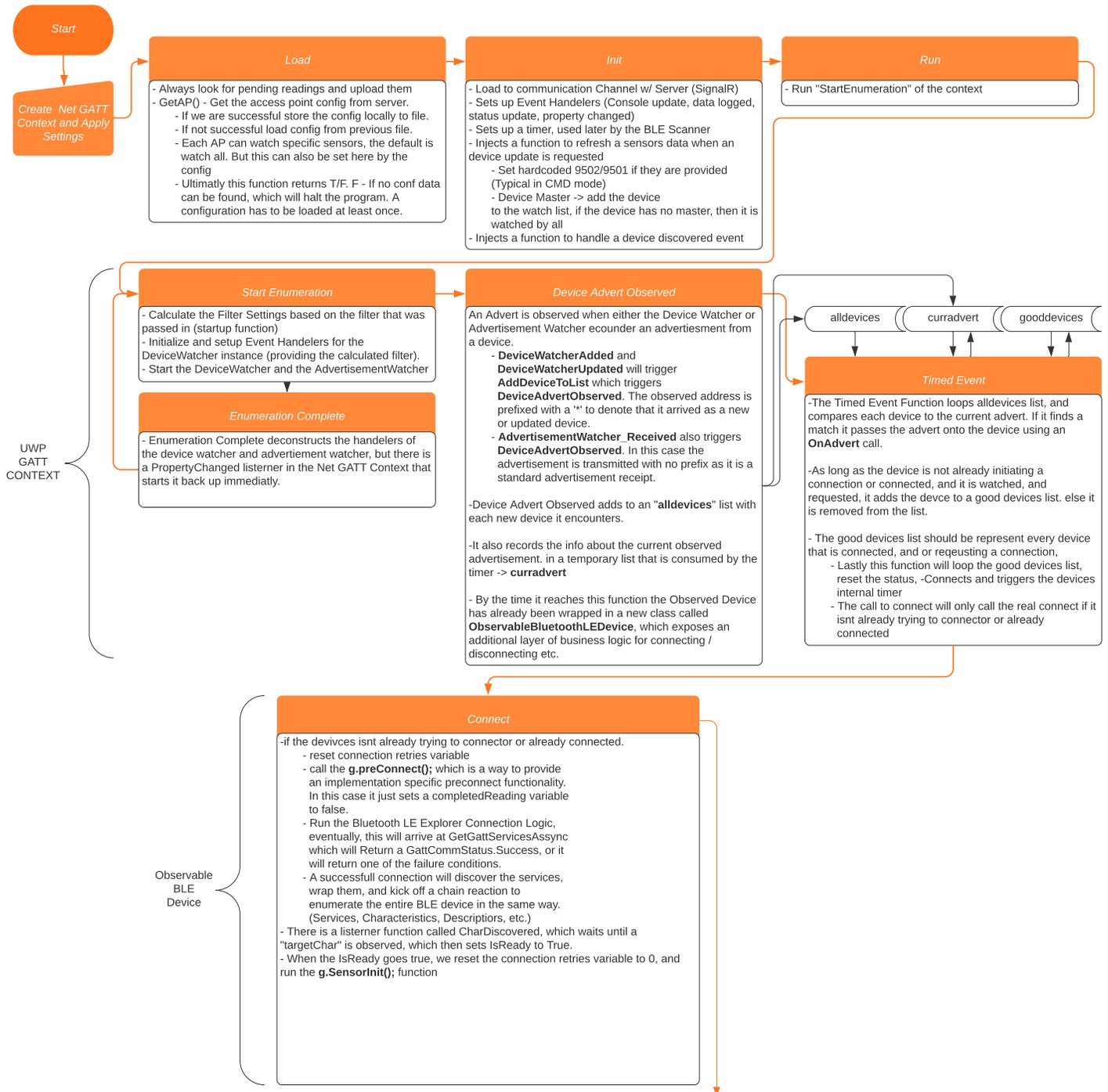
If the collection of all readings is successful, the Success command is executed, and the reader returns the data to the original NETGattSampleContext through an Action object. The NETGattSampleContext receives the data and posts it to the server, or saves it to a file.

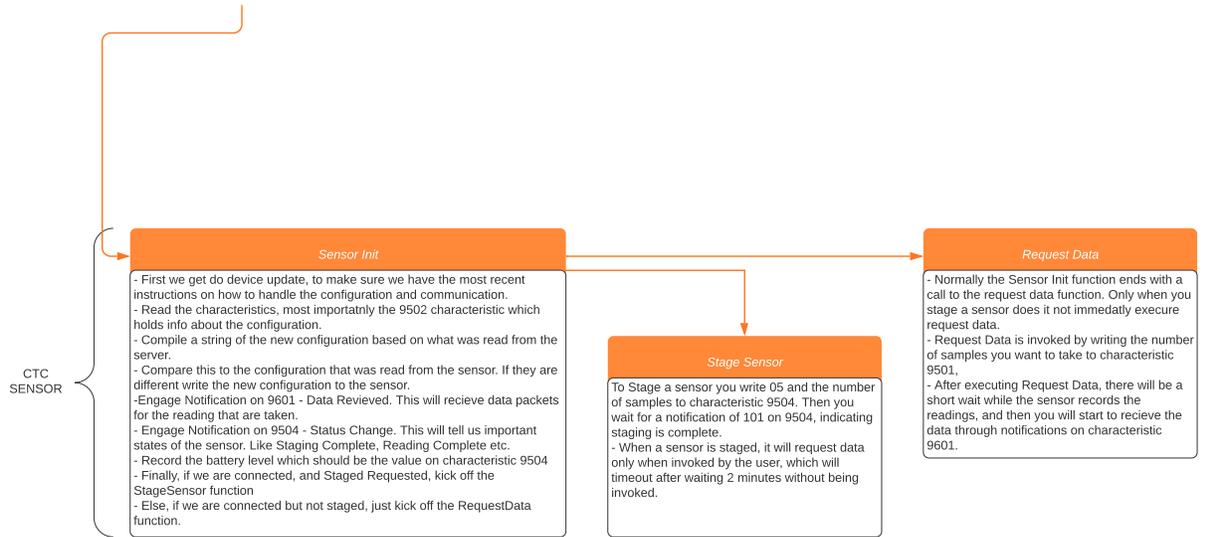
Finally, the Reader disconnects from the sensor. That concludes the reading.



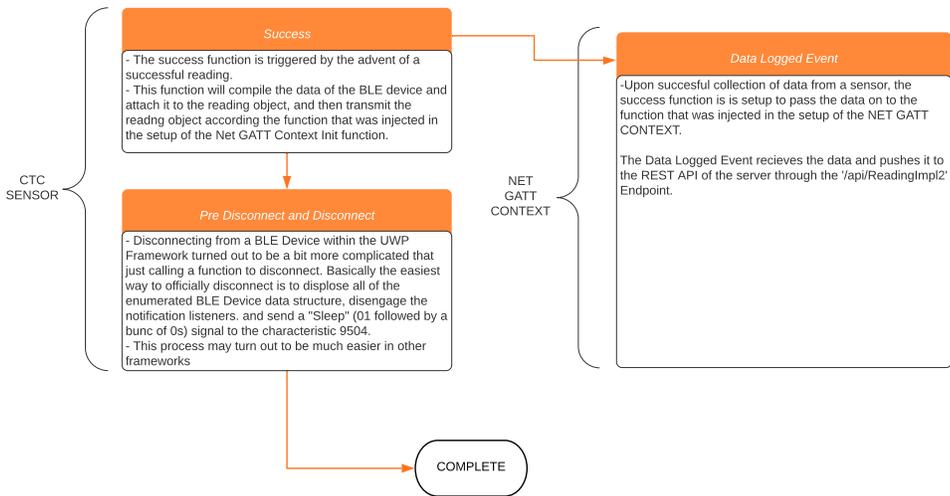
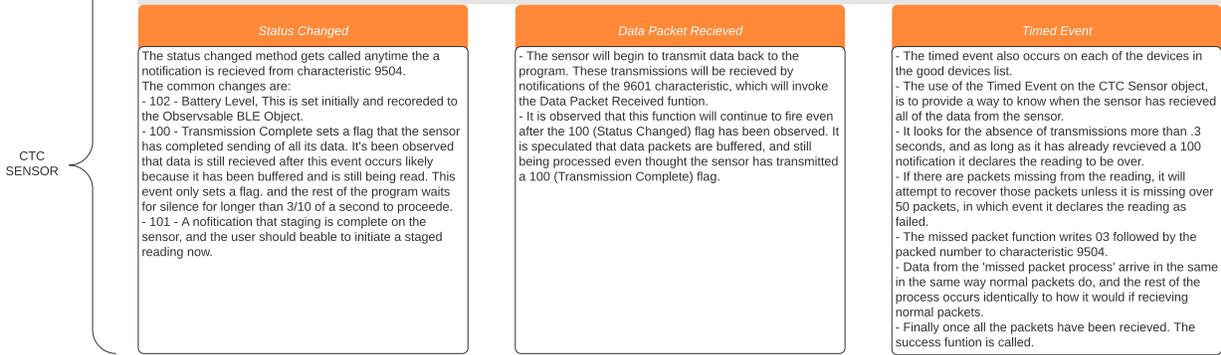
Wireless Access Point Process Flow

Shaun McLarney | March 16, 2020





Although not connected directly as shown in this diagram these three functions behave asynchronously and receive data at different times, but they all work together to build up a reading and process it by passing it on to the success function.



Universal Bluetooth Integration

This section provides a second, more platform-agnostic approach to capturing a signal. It's intended for those who want to take readings directly from the sensor but don't want to review our code examples or source code to get the generic process for taking a reading.

Understanding the Data Structure of the CTC Sensor

1. Download Microsoft's Bluetooth LE Explorer App to assist in understating the workflow.
2. Follow steps 1-8 describing the Bluetooth LE Explorer in the Troubleshooting guide on page 71 to get a live example of the scan below.

```

Service Name: GenericAccess
Service UUID: 00001800-0000-1000-8000-00805f9b34fb

Characteristic Name: DeviceName - User Description: - Handle: 2 - Value: CTCWS_EDD562

Characteristic Name: Appearance - User Description: - Handle: 4 - Value: 00-00

Characteristic Name: PeripheralPreferredConnectionParameters - User Description: - Handle: 6 - Value: 06-00-A0-00-00-00-90-01

Characteristic Name: CentralAddressResolution - User Description: - Handle: 8 - Value: 01

Service Name: GenericAttribute
Service UUID: 00001801-0000-1000-8000-00805f9b34fb

Service Name: 00009500-7777-efde-5151-7892818b7a71
Service UUID: 00009500-7777-efde-5151-7892818b7a71

Characteristic Name: 00009501-7777-efde-5151-7892818b7a71 - User Description: - Handle: 12 - Value: 00-00-01-F4
Characteristic Name: 00009502-7777-efde-5151-7892818b7a71 - User Description: - Handle: 14 - Value: 01-00-00-00-00-0D-02-02-FF-C8-81-80
Characteristic Name: 00009503-7777-efde-5151-7892818b7a71 - User Description: - Handle: 16 - Value: 00-03-D0-90
Characteristic Name: 00009504-7777-efde-5151-7892818b7a71 - User Description: - Handle: 18 - Value: 66-16-35-00-00

Service Name: 00009600-7777-efde-5151-7892818b7a71
Service UUID: 00009600-7777-efde-5151-7892818b7a71
Characteristic Name: 00009601-7777-efde-5151-7892818b7a71 - User Description: - Handle: 22 - Value: 00-00-04-38-06-98-06-80-06-B2-06-81-06-9C-06-81-06-8A-06-90-06-80-06-81-06-96-06-82-06-B8-06-81-06-80-06-84-06-92-06-84-06-86-06-8A-06-8A-06-91-06-80-06-B4-06-B1-06-80-06-90-06-80-06-87-06-8C-06-88-06-90-06-80-06-B5-06-80-06-9E-06-90-06-88-06-81-06-88-06-88-06-91-06-82-06-B5-06-B0-06-80-06-90-06-88-06-88-06-80-06-88-06-94-06-80-06-80-06-81-06-9F-06-86-06-80-06-84-06-88-06-88-06-91-06-82-06-B0-06-80-06-80-06-91-06-81-06-86-06-8C-06-8A-06-98-06-80-06-B4-06-B0-06-9E-06-90-06-80-06-90-06-8A-06-80-06-93-06-80-06-B1-06-AF-06-80-06-90-06-80-06-80-06-88-06-8B-06-95-06-80-06-B6-06-81-06-80-06-90-06-80-06-90-06-88-06-8C-06-92-06-81-06-B8-06-80-06-81-06-90-06-8F-06-90-06-8C-06-80-06-98-06-82-06-B8-06-B0-06-A0-06-80-06-80-06-91-06-8A-06-89-AE-09-BA-7E-8F-A8-FC-0C-EA

Service Name: DeviceInformation
Service UUID: 0000180a-0000-1000-8000-00805f9b34fb

Characteristic Name: ManufacturerNameString - User Description: - Handle: 26 - Value: Connection Technology Center, Inc

Characteristic Name: ModelNumberString - User Description: - Handle: 28 - Value: WA102-1A

Characteristic Name: HardwareRevisionString - User Description: - Handle: 30 - Value: WAP10001_D

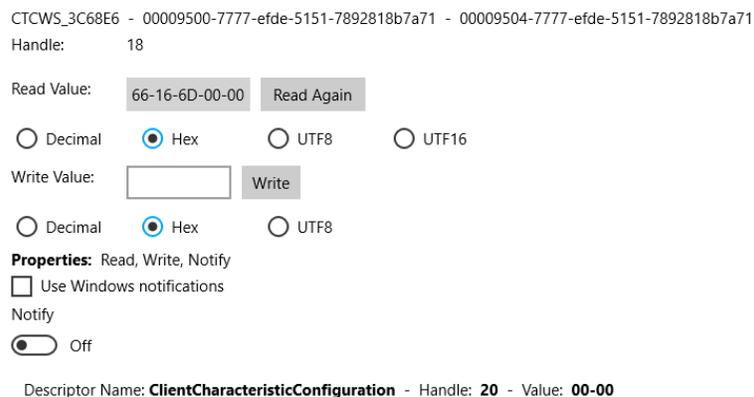
Characteristic Name: FirmwareRevisionString - User Description: - Handle: 32 - Value: 2.4

Characteristic Name: SoftwareRevisionString - User Description: - Handle: 34 - Value: 6.1.0
    
```

3. The highlighted sections represent the essential characteristics to notate. This manual will refer to them by the last four characters of the first block, i.e., 9501,9502, and so on.
 - a. 9501 - The number of samples to read
 - b. 9502 - The configuration of the sensor



- c. 9503 - The max memory size of the sensor read-only
 - d. 9504 - The sensor status
 - e. 9601 – The reading data
4. Clicking on individual characteristics inside the BLE Explorer app provides more information about how they can interact.
 5. Clicking on 9504 or 9601 will display a Notify toggle. This is available because the CTC Sensor expects that the user will enable Notifications on these characteristics to take readings. Enabling this feature in any programming language will prime the sensor to send back information about status and readings, as these events occur.



6. Characteristics 9501,9502, and 9503 will display values. These values are in hex and need to be converted to decimal. If a reading has never been taken before, these values will also appear random. A reading has been taken in the previous example, so the output below will have logical conclusions.
 - a. 9501 - The number of samples to read: 0x000001F4 -> 500
 - b. 9502 - The configuration of the sensor -> 0x0F000000A0D0002FFFF0000. Please refer pages 31 and 32 for details on parsing these values.
 - c. 9503 – This value is for reference, and describes the max memory size of the sensor. Don't initiate a reading that will exceed the following value: 0x0003D090 -> 250000
7. 9501,9502 will be overwritten whenever a reading is taken.

Taking a Reading

1. Read the configuration (9502) of the sensor to variable "_C"
2. Decide how many samples will be requested in hex as variable "S", i.e. 500 -> 0x000001F4



- 3.** Compile the configuration of the sensor in hex as variable "C". Please review pages 31 and 32 to compile this value.
- 4.** Write the value of C to characteristic 9502. Please note that this is only necessary if the value needs to be changed. Compare values _C and C to determine if an update is required. Optionally, specifically targeted variables in 9502 can be changed by hardcoding 0s into other parts of the 9502 configuration.
- 5.** Enable notifications on both 9504 or 9601.
- 6.** Writing the value of S to characteristic 9501 will initiate the reading.
- 7.** As the readings start to come in on 9601, record them to a buffer object containing entities that consist of a packet number and a reading value array or string.
- 8.** Multiple reading responses will be received, and a potential status change in 9504 by the time all packets have been received.
 - a.** The status change in 9504 to a value of 100 indicates that the sensor's transfer has finished.
 - b.** While this value indicates completion on the sensor side, the operating system usually has its own buffer to handle the incoming data, which it turns over to the program when it is ready. As such, a 9504 value of 100 may come in before the readings are done.
 - c.** Once the readings stop (usually indicated by silence for more than half a second), begin to process the readings, check that all of the packets have arrived, and then begin converting the byte arrays that you received into an integer array. Please refer to the BLE Data Structure Excel file for more information on how to interpret a reading. To convert the integer values to mV, multiply the value by 3600 and divide by 4096.
 - d.** The result should be a collection of numbered packets that the user can concatenate into a time waveform.
 - e.** This will provide waveform data for its intended end use.
- 9.** Put the sensor to sleep if that is part of the configuration. This is done by writing 1 to the status characteristic 9504 (A sleep value of 0 in the configuration will not sleep the sensor, but should assist in disconnect)
- 10.** Clean up application memory (dispose of objects, deallocate memory, etc.), and disconnect from the sensor.
- 11.** Repeat as necessary for all sensors.



Further Information

- 1.** Refer to the BLE Data Structure document for more detailed information on status requests that can be sent.
 - a.** Other status scenarios include retrieving the battery level, handling a missing data packet or reading, etc.
- 2.** Review the Standalone Reader section on pages 28-34 of this manual, as this provides more specific details about the characteristics that would help compile data to initiate a reading.
- 3.** Lastly, refer to the first section of the Developer's Guide beginning on page 35, or request a link to our open source project of the CTC Wireless application to review our code for a better understanding.

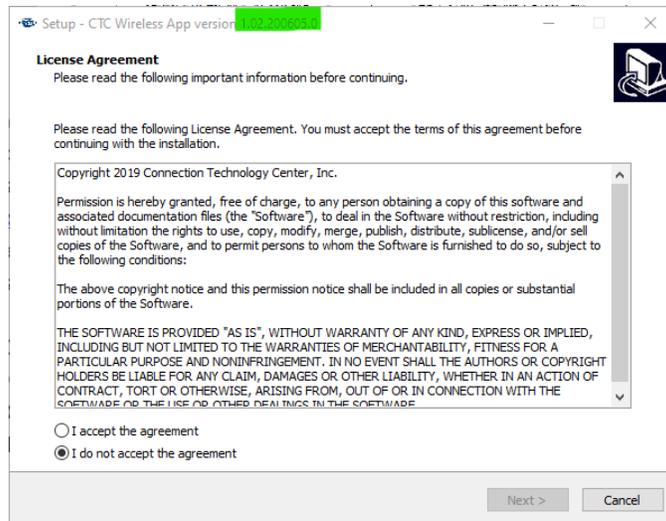


This troubleshooting guide assumes that all of the prerequisites to running the CTC software have been installed on a computer with compatible Bluetooth hardware, running on the appropriate updated version of Windows 10.

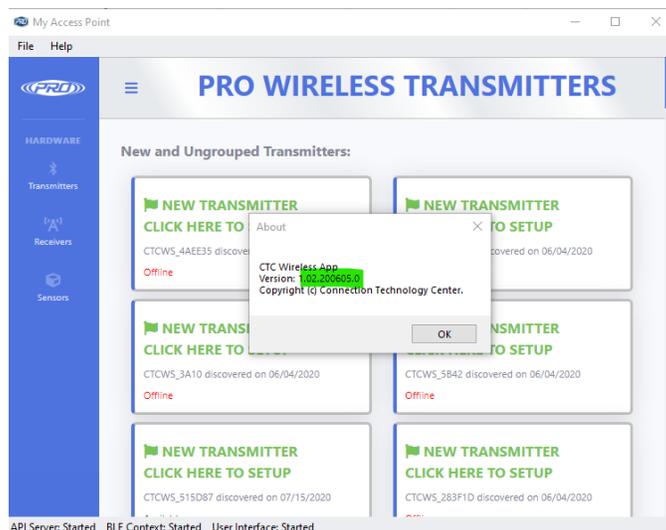
Keeping the software up-to-date

Make sure the computer is running the latest version of the software. (This section is not applicable for a first-time installation on a new computer.)

1. Using the following address, open the CTC website and download the latest version: https://www.ctconline.com/ctcws/ctc_wireless_installer.zip.
2. The following window while running the installer, which will identify the version (highlighted in green). Record this number for reference, and close the installer.



3. Open the software, click the Help menu, and click the About option. The resulting dialog box will display the version number.

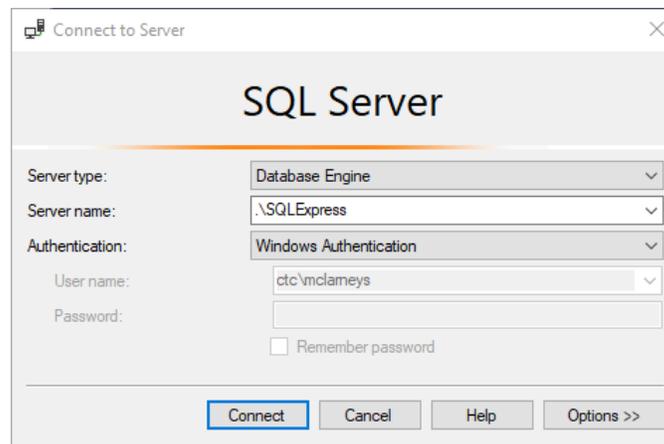


4. If the Help menu and About option are absent, the current software platform is a prerelease version. Uninstall the software and proceed to the "SQL Server Schema Updates" section, as the database must be deleted to perform the reinstall.
5. Reinstall the software.
6. Review the release notes under Help -> Change Log. If the words "schema change" appear between the previously installed version and the newer version, the version migration SQL scripts must be run. The location of these scripts will be noted in the changelog. Proceed to the "SQL Server Schema Updates" section to complete the installation of the change scripts.

Please Note: Updates must be installed sequentially from the currently installed version to the next newest until the software is up to date.

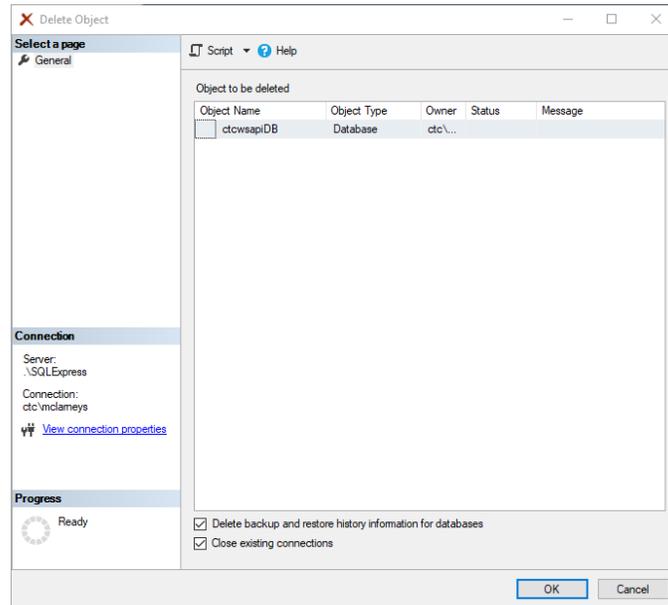
SQL Server Schema Updates.

1. Using the following address, download and install Microsoft SQL Management Studio to update the database: <https://docs.microsoft.com/en-us/sql/ssms/download-sql-server-management-studio-ssms?view=sql-server-ver15>.
2. When opening Microsoft SQL Management Studio for the first time, the defaults should allow users to log directly into the local database.

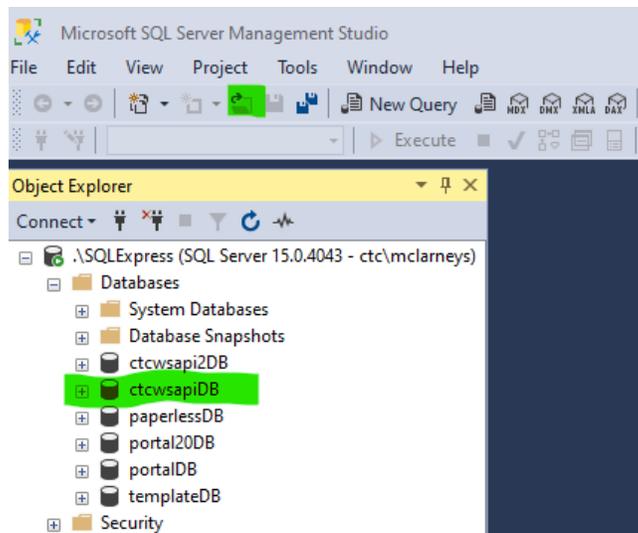


3. Expand Databases and find the "ctcwsapidb" database.
4. If deleting the database from a prerelease version of the CTC software:
 - a. Right-click the database and choose "Delete."

- b.** Check the box titled “Close existing connections” in the window that pops up, and press OK.



- c.** Once this completes successfully, reopen the latest version of the CTC software. This will automatically connect and rebuild the database to the newest version.
- 5.** When installing version migration scripts:
- a.** Make sure “ctcwsapidb” is selected, and choose File > Open and navigate to the file noted in the changelogs.

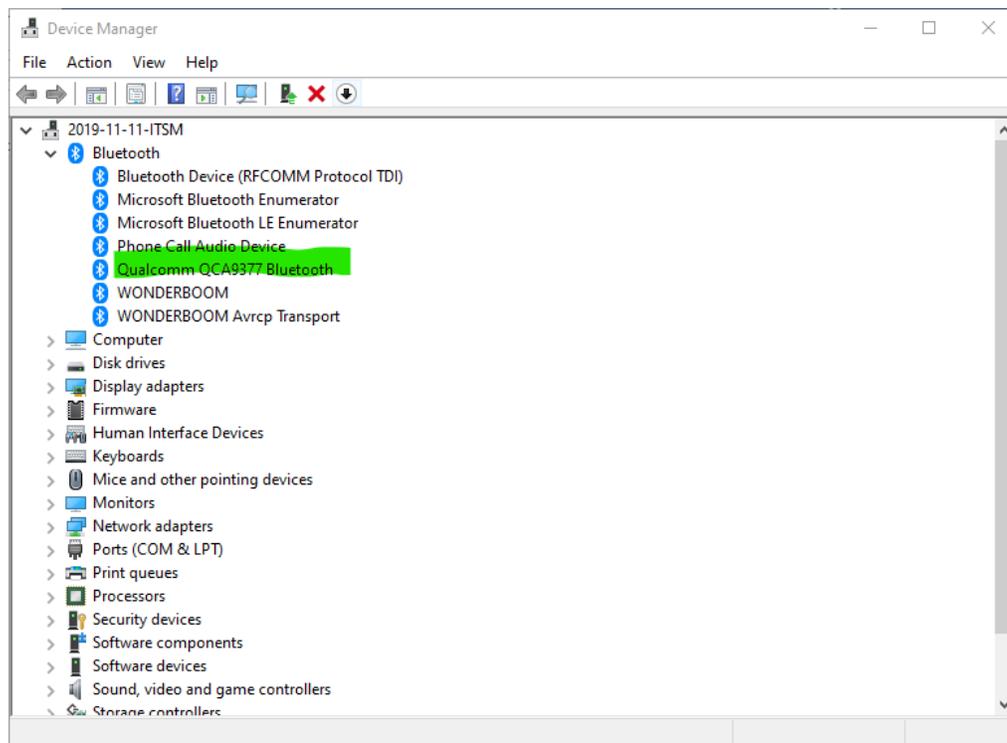


- b.** Click the “Execute” button.

Bluetooth Driver

If the driver for your Bluetooth hardware is out of date, follow these steps to update.

1. Right-click the Windows start button in the lower-left of the screen and choose "Device Manager" from the menu that pops up.
2. Find the Folder called "Bluetooth" and expand it.
3. Look for a Bluetooth device with a vendor name next to it.



4. Right-click that device and choose update driver.
5. If this does not work, Google the name of the device and the word "driver."
 - a. In the image above, it would be "Qualcomm QCA9377 Bluetooth Driver."
 - b. Download and reinstall the driver from the manufacturer's website.

Diagnosing Connection Issues

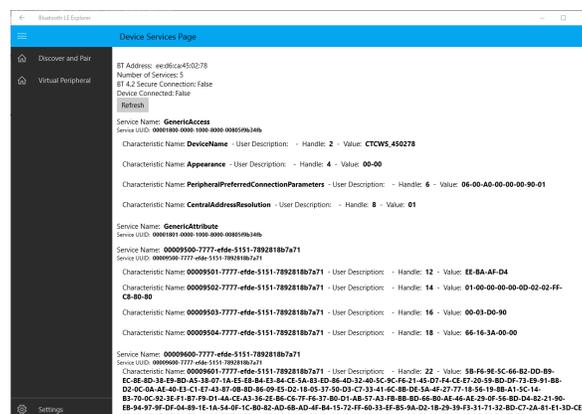
1. The CTC Wireless Software can decouple the execution of the reader software from the graphical software.
2. In the software, click the File then Settings.

10. A successful reading should look like the previous screens. There may not be as many lines if there are only 1 or 2 sensors, but if the reading is successful and a timewave form and FFT open on the screen, the output of those lines will represent a reading from beginning to end.
11. If the application is having difficulty connecting, the computer may be too far away from the sensor or there is too much interference. This can be identified by looking at the numbers in parenthesis –
 - a. 08:06:50 - CTCWS_4AEE35(-77)1 - 1011 - 1010 - Requesting-DeviceStatus
 - b. Difficulties may begin to occur when this number is -82 or lower.
12. If no sensors are shown and do not show up after 15-30 seconds, go to the next section, "Bluetooth LE Explorer."

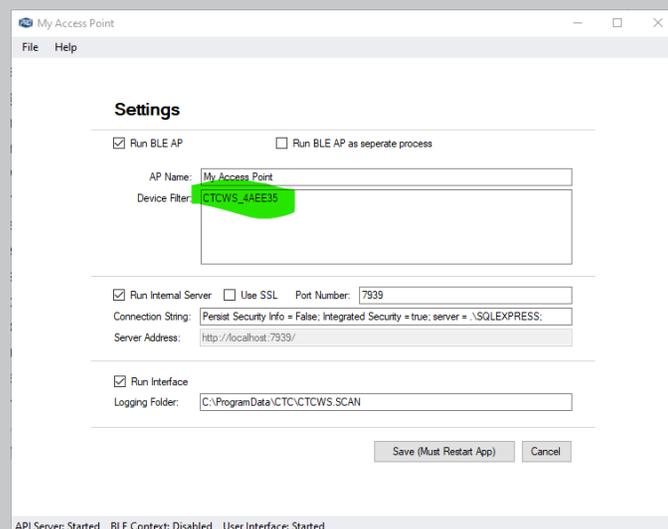
Bluetooth LE Explorer

This is an application from Microsoft that we have found useful in ruling out hardware related issues for the variety of makes and models of computers that run our software.

1. On a Windows 10 computer, open the Microsoft store.
2. Click the search button and type "Bluetooth LE Explorer."
3. Install the application.
4. Once the application is installed, run it from the start menu.
5. Click the "Continuous Enumeration" checkbox, type "CTCWS" in the Filter, then click the "Start" button.
6. The application will begin to scan for CTC Bluetooth sensors.
7. When one appears, click in the blue area of the found sensor. **Do not click the pair button.**
8. This action will initiate a connection and enumerate all the properties of the sensor; the same was as the CTC software. If you see a new window that looks like this, it means that your computer was able to enumerate the device successfully, and everything should be ready to go for the CTC application to take readings.



9. If any error messages appear, the sensor may be out of range or be incompatible with the Bluetooth hardware in use.
 - a. Keep in mind that occasional connectivity errors may occur, due to line of sight, range, or other environmental interference. The CTC software deals with this by implementing a retry mechanism; however, in some cases, it will continue to retry for over 15 minutes and never be able to take a reading. While the software typically takes a reading in 20-45 seconds. It is possible that in scenarios of high interference, it could take up to 2-3 minutes to take a successful reading.
 - b. First, take the sensor into an area largely devoid of radio interference. Place the computer as close as possible to the sensor as (i.e., < 10 ft.) and attempt to connect as described above.
1. Upon connection, open the CTC software and attempt to take a reading.
 2. If a reading is successfully taken, take several more to determine that connectivity is not due to a hardware issue.
 3. Reinstall the sensor and take additional readings.
 4. If readings can reliably be taken in the test above but not in the desired installation setting, there is likely an environmental factor preventing the CTC wireless sensor from communicating successfully.
 5. In the CTC Wireless Software, click file then settings. In the filter field, enter one or more wireless sensors (comma separated). Type the id of the sensor, usually "CTCWS_" followed the six-character serial code. Click Save and restart the app. Repeat steps 1-4.



- c.** If this does not solve the issue, reboot the computer and try again.
- d.** If you continue to see errors, go back to the section of this troubleshooting document that explains how to reinstall your Bluetooth driver, and make sure you have the latest driver for your Bluetooth hardware.
- e.** If all else fails, or you see the application partially working, but not consistently, you may not have Bluetooth hardware that is compatible with our wireless sensors. We recommend that you head out to your local computer supply store, purchase and install a new Bluetooth 5.0 USB dongle, or head over to the CTC website and purchase the tablet that we offer for taking readings from the CTC Wireless Sensor.

How close does my tablet need to be to the desired transmitter to receive data?

The tablet must be within 150 ft. of the desired wireless transmitter in order to receive data.

Will my tablet still receive data if there are obstructions between the tablet and the transmitter?

BLE Bluetooth signals will allow for some level of obstructions. The material composition of obstruction will determine the level of signal loss. We have seen moderate signal loss with materials like drywall, and complete signal loss with other materials like reinforced concrete. Any obstructions will produce some level of signal loss and reduce the maximum distance you are able to receive data within. For best performance, Line-of-Sight is recommended.

If my tablet is not within 150 ft. of the transmitter, can I daisy chain transmitters to collect data?

No, the tablet must be within 150 ft. of the desired wireless transmitter.

Does the Transmitter store data?

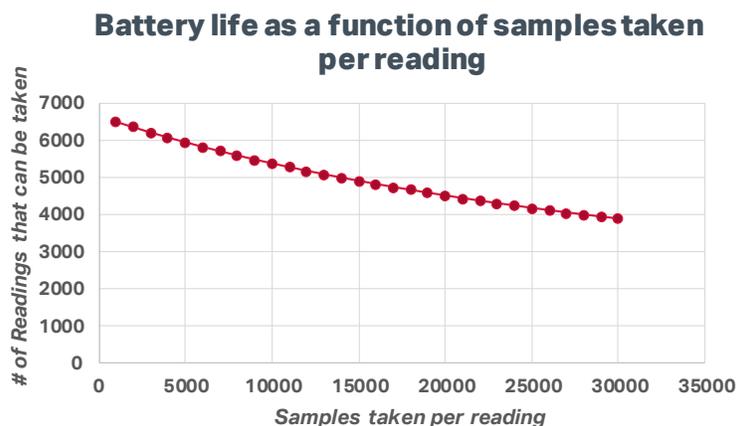
The Access-Point / Receiver is the primary storage location of data. The transmitter only stores 1 reading at a time, once this reading is transmitted to the receiver and overwritten with the next reading.

How many readings do CTC wireless transmitters take per day?

The number of readings is a user defined setting.

What is the battery life of WA100 Series Transmitters?

Battery life varies depending upon the number & type of readings, and the environment the transmitter is in. The more readings taken per day, the shorter the battery life will be.



Is battery life covered under warranty?

Battery life is not covered under CTC warranty.

Is the battery on my WA100 Series transmitter replaceable or rechargeable?

No, WA100 Series transmitters are disposable units. The molded design seals the transmitter from the environment, and therefore does not allow for replaceable or rechargeable batteries.

Will my WA100 Tablet talk to my data analyzer?

Various analyzers support data import. The CTC Wireless Software that runs on our tablet and access point will provide the data in a variety of common formats that can be used for data import/export.

Is the data processing done in the sensor or the software?

The data processing is done in the software. The Wireless transmitter collects the data, which is transferred to the tablet and processed using CTC wireless software.

Do I own my data?

Yes, CTC wireless transmitter users own 100% of data collected.

Can I "nickname" sensors?

Yes, you can nickname sensors. CTC suggests renaming transmitters to note their location and position on the machine they are monitoring.

Can I create groups of transmitters?

Yes, you can create transmitter groups. Transmitter groups are typically used to logically group all the transmitters associated with a single machine.

What format is my data stored in?

The raw data is fed through Bluetooth Characteristics, the software converts the raw Bluetooth data to a JSON file format which is fed into a Microsoft SQL Database.

How many readings will my tablet store?

Out of the box, the tablet will store over 100,000 readings. The number of readings is only limited by the storage space of the tablet. Storage is expandable through the Micro SD slot.

How can I access historical readings?

Historical readings are accessible through each transmitter reading view in the CTC Software, or directly through the SQL database.



Is there a lag time between when the reading is taken and when I can view my data?

Yes, the lag time is related to how long it takes the transmitter to collect and transmit the signal. For instance, a reading of 10000 data points @ 1000 Hz will take 10 seconds to complete, the time to transmit will take a couple of seconds. With more readings, the transmission will take proportionally longer. Signal strength also plays a factor in transmission speed.

What is the IP rating of CTC wireless transmitters?

WA102 carries an IP67 rating, which means it will remain protected and fully operational in almost all industrial applications, including those where the transmitter is exposed to water spray, precipitation, dust, and other airborne fine particles.

