## Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Specialty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brian Brigandi Jr.</td>
<td><a href="mailto:brian.brigandi@gmail.com">brian.brigandi@gmail.com</a></td>
<td>Team member. Specialty with AHK as well as meter access.</td>
</tr>
<tr>
<td>Mark Joseph</td>
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<td>Team member. Specialty with meter access and LabView program.</td>
</tr>
<tr>
<td>Johnathan Sisk</td>
<td><a href="mailto:jcsisk21@gmail.com">jcsisk21@gmail.com</a></td>
<td>Team member. Specialty with meter access and LabView program</td>
</tr>
<tr>
<td>Olivia Trinko</td>
<td><a href="mailto:olivia.trinko@gmail.com">olivia.trinko@gmail.com</a></td>
<td>Team member. Specialty with meter access and LabView program</td>
</tr>
<tr>
<td>Dr. Sid</td>
<td><a href="mailto:ssuryana@rams.colostate.edu">ssuryana@rams.colostate.edu</a></td>
<td>Senior Design Professor</td>
</tr>
<tr>
<td>Kirk Evans</td>
<td><a href="mailto:kirk.evans@colostate.edu">kirk.evans@colostate.edu</a></td>
<td>Kirk works at the Power House and is knowledgeable of the Eaton meter located in the shop.</td>
</tr>
<tr>
<td>Chuck Sawyer</td>
<td><a href="mailto:Charles.sawyer@colostate.edu">Charles.sawyer@colostate.edu</a></td>
<td>Chuck is a technician on campus that is a good reference for accessing the Eaton meters on campus wirelessly through the CSU network.</td>
</tr>
<tr>
<td>John Seim</td>
<td><a href="mailto:johnseim@engr.colostate.edu">johnseim@engr.colostate.edu</a></td>
<td>John works in the office between Engineering C105 and C107. He is a good reference for computer trouble and is able to download LabView on your laptops.</td>
</tr>
</tbody>
</table>
## Document Revisions

<table>
<thead>
<tr>
<th>Date</th>
<th>Version Number</th>
<th>Document Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>03/30/2015</td>
<td>1</td>
<td>Initial Draft</td>
</tr>
<tr>
<td>04/05/2015</td>
<td>2</td>
<td>Addition of Wired and Wireless Meter Access</td>
</tr>
<tr>
<td>04/15/2015</td>
<td>3</td>
<td>E-Days Edits</td>
</tr>
<tr>
<td>04/29/2015</td>
<td>4</td>
<td>Adding AHK Support Section</td>
</tr>
<tr>
<td>05/02/2015</td>
<td>5</td>
<td>Adding Labview Programming Section</td>
</tr>
<tr>
<td>05/04/2015</td>
<td>6</td>
<td>Final Edits and adjustments</td>
</tr>
</tbody>
</table>
# Table of Contents

1 Introduction ..........................................................................................................................5  
1.1....Scope and Purpose ........................................................................................................5  
1.2....Guide Overview ............................................................................................................5  

2 Accessing Meter via Wired Connection ..............................................................................6  
2.1....Locating the Meter ......................................................................................................7  
2.2....Necessary Computer Changes ..................................................................................12  
2.3....Accessing the Meter ..................................................................................................19  
2.4....Troubleshooting .......................................................................................................21  

3 Accessing Meter via Wireless Connection .........................................................................22  
3.1....Necessary Computer Changes ..................................................................................23  
3.2....Wireless Access ........................................................................................................26  
3.3....Troubleshooting .......................................................................................................30  

4 Saving Waveform Data ......................................................................................................31  
4.1....Starting Point .............................................................................................................32  
4.2....Saving Data Through Meter Interface ......................................................................33  

5 AutoHotKey Programming .................................................................................................34  
5.1....Creating an AutoHotKey file ......................................................................................35  
5.2....Establishing a hotkey .................................................................................................36  
5.3....Using the click function ............................................................................................37  
5.4....Using the sleep function ...........................................................................................38  
5.5....Using the send function ............................................................................................39  
5.6....Loops .........................................................................................................................40  
5.7....Running the Program ...............................................................................................41  

6 Labview Programming .......................................................................................................44  
6.1....Inputting Waveform Data ..........................................................................................45  
6.2....Asymmetry Factor .....................................................................................................48  
6.3....Total Harmonic Distortion (THD) ............................................................................49  
6.4....CBEMA Compliance ...............................................................................................51  

7 Our AutoHotkey Program ................................................................................................53  
7.1....Process of the Program ............................................................................................54  
7.2....Necessary Changes ..................................................................................................60
1 Introduction

1.1 Scope and Purpose
This document is intended to help future teams working on this continuation project better understand the processes that our team used in order to accomplish certain tasks. In this document you will find general instructions that will help explain our teams LabView program and AutoHotKey program as well as the method for accessing the power quality meters on campus that were used for obtaining the waveform data.

1.2 Guide Overview
Using this document you will find all the information that you need in order to run the program that our team finished with. It will cover everything from getting access to the meter to running the waveform data through LabView.

The guides contained in this document are listed below:

1. Accessing Power Quality Meters and updating Java
2. Saving Waveform Data
3. AutoHotKey Programming
4. Understanding the LabView program
2 Accessing Meter via Wired Connection

One method of accessing the Eaton Xpert 8000 meter is through a wired connection. This method uses an Ethernet cable connected directly to the meter. This method is reliable and does not require a secure server like the wireless connection method does. However, the user is restricted by the physical limiting factor of the length of the Ethernet cable.

This method requires the following items:

- Ethernet Cable
- Laptop
- Appropriate Clothing (Pants and closed toed shoes)

There exist many different meters across Colorado State University’s campus. This tutorial however will only discuss how to access the meter within the Colorado State University’s Powerhouse. Similar processes can be used to access the other meter located on Colorado State University’s campus.
2.1 Locating the Meter

The meter used in the Real Time Meter Data to Metrics project is located at the Colorado State University Powerhouse. The Powerhouse is located at:

**Engines & Energy Conversion Lab**

**430 N College Ave**

**Fort Collins, CO 80524**

To reach the Powerhouse from Colorado State University’s Campus:

1. Start at Colorado State University
2. Head east on W Laurel St toward Rembrandt Dr. (0.2 mi)
3. Turn left onto US-287 N/S College Ave (1.1 mi)
4. End at the CSU Powerhouse on your right

Note: Parking is usually limited at the Powerhouse, but there is a parking lot (Red Box) across the train tracks. Parking in this lot is free. From here just walk across the field to the Powerhouse (Green Arrow).
Once the user is at the Powerhouse enter through the front doors and take a left in the main hallway and process straight ahead. This door (Red Box) can be seen at the end of the hall it leads into the engines lab, which is where the meter is located:

Important: The engines lab requires all users to wear closed toed shoes and pants.
REAL TIME METER DATA TO METRICS

Enter through the door into the engines lab and continue straight ahead until you reach the switch gear (Red Box) to the right:
Approach the switch gear and on the end that is closest to the windows is the meter. The meter display (Red Box) is mounted on the side of the switch gear:
REAL TIME METER DATA TO METRICS

As noted the meter display is located on the side of the switch gear, however the actually meter (Red Box) is located on top of the switch gear:

Note: Since the meter is located on top of the switch gear a chair or stool will be needed in order to access the meter.
2.2 Necessary Computer Changes
To access the meter some necessary changes will need to be made before the user will be able to access the meter. One of these changes is in the IPv4 Address. This address need to be “198.168.1.100”. In addition the Subnet Mask must be “255.255.255.0”. Both of these can be checked by opening the command prompt on the laptop and then typing the command “ipconfig”. It will display both of these in the command prompt:

If the network settings are not set to these specifications they will need to be changed. To change the IPv4 Address the user should type “ipconfig 192.168.1.100” into the command prompt. This will change the IPv4 Address.

Note: The following process for changing the subnet mask is using a Window 8 operating system. If using a different operating system the user might have to make some changes to the following tutorial. The method used is call “Setting up with static IP address”. The user therefore can be search this process and their specific operating system to determine what to do.
REAL TIME METER DATA TO METRICS

To change the subnet mask the user must open the control panel. One the control panel is open the user should navigate to the “Network and Internet” (Red Box):

Once “Network and Internet” is selected the user should then click the “Network and Sharing Center” (Red Box):
Note: At this process it might be necessary to plug in the Ethernet Cable. This process can be seen in section 3.3 Accessing the Meter.

Now the user should navigate and select the current network that is connected. (Red Box):

From here the user can see the status of the connection and should click on “Properties” (Red Box):
REAL TIME METER DATA TO METRICS

Once the network properties is open, the user should scroll and locate “Internet Protocol Version 4 (TCP/IPv4)”. Once located the user should select this tab and click “Properties” (Red Box):

Now the user can select “Use the Following IP Address” and enter in the following addresses. Once the addresses are entered select “OK”. Now your network settings are set up correctly.
Once these network settings are configured the next step is to install a working version of Java. When accessing the meter the website will communicate that the meter requires the latest version of Java. However if the user installs the latest version of Java the security settings of Java will block access to the meter. Therefore the user must install Java 7. If unsure what version of Java the computer has installed on it the user can check this by opening the start menu and locating the Java folder. Once the Java folder is located open it and click on “Configure Java”. This will open the Java control panel as seen here:
Once the control panel is open click on “About”. This will indicate what version of Java is being used as seen here:

In this case Version 7 Update 60 is being used. Therefore this version of Java would be functional. If the Version of Java is anything other than 7 accessing the meter will mostly likely not work. The update number does not matter for accessing the meter.

If Java Version 7 is not installed the user should search the internet for Version 7. Once the user locates Version 7 they should download and install this version to their computer.

**Important: Do NOT uninstall previous versions of Java until Java Version 7 has been installed.**
Once Java version 7 is installed, the user should manually go uninstall any version of Java that is greater than Version 7.

Now the user should open the Java Control Panel by clicking “Configure Java”. Next they should open click the “Security” tab. From here the user should adjust the Security Settings to “Medium” like so:

![Java Control Panel Security Settings](image)

Once this is done the user should click “Apply” and then “OK” and now the user’s computer is ready to access the meter.
2.3 Accessing the Meter

The user should now connect the Ethernet cord to the meter. The user can do this by plugging in one end of the Ethernet cable to the user’s laptop and the other end to Ethernet port (Red Box) on top of the meter, as seen here:
REAL TIME METER DATA TO METRICS

To access the Meter a variety of browsers have worked, but the most consistent of these browsers are Firefox or Chrome. If the user does not have Firefox or Chrome installed the user should install these browsers and test each for functionality. Following the installation of these browsers the user should open the Firefox or Chrome browser. In the address bar the user should then type “192.168.1.1”:

The user should then click “Enter” and access the meter and the following screen will be done if the meter has successfully connected to the user’s laptop:
2.4 Trouble Shooting

- To check the network connection when the laptop is connected to the meter the user should open the computer’s command prompt. Once the command prompt is open the user should type in the command “ping 192.168.1.1” and press “Enter”. The “ping” command sends four test pulses. If the connection is functional the user the “ping” command will return all four of these pulses. If the connection is not working the “ping” command will not return the pulses and the will be considered “lost”. The following image illustrates what a functioning connection would look like:

- If the user is still having problems accessing the meter the user should Turn OFF WIFI on the computer. The user should close all programs and restart all programs and check if they have established connectivity.

- If the user is still having trouble accessing the meter the user can call Eaton for technical support:

  Eaton Technical Support: 877-386-2273  Option 2 then Option 4
3 Accessing Meter via Wireless Connection

Another method of accessing the Eaton Xpert 8000 meter is through a wireless connection. This method uses Colorado State University’s wireless network to connect to the meter. This method allows the user to access the meter anywhere on Colorado State University’s campus as long as the user is connected to the WIFI network.

This method requires:

- Laptop

There exist many different meters across Colorado State University’s campus. Using the wireless connection method allows the user to access different meters by using their specific IP address. Therefore any of the meters can be accessed as long as the appropriate IP address is entered. These are a list of the meters across Colorado State University’s Campus:

<table>
<thead>
<tr>
<th>Location</th>
<th>IP address</th>
</tr>
</thead>
<tbody>
<tr>
<td>NESB</td>
<td>10.1.252.25</td>
</tr>
<tr>
<td>Education</td>
<td>10.1.252.27</td>
</tr>
<tr>
<td>Chemistry</td>
<td>10.1.252.28</td>
</tr>
<tr>
<td>Eddy (no comms - construction)</td>
<td>10.1.2520.29</td>
</tr>
<tr>
<td>Engineering Main</td>
<td>10.1.252.30</td>
</tr>
<tr>
<td>Engr. Computer Center</td>
<td>10.1.252.31</td>
</tr>
<tr>
<td>ERC B-Wing</td>
<td>10.1.252.32</td>
</tr>
<tr>
<td>District Cooling Plant #1</td>
<td>10.1.252.33</td>
</tr>
</tbody>
</table>
3.1 Necessary Computer Changes

To access the meter some necessary changes will need to be made before the user will be able to access the meter. When accessing the meter the website will communicate that the meter requires the latest version of Java. However if the user installs the latest version of Java the security settings of Java will block access to the meter. Therefore the user must install Java 7. If unsure what version of Java the computer has installed on it the user can check this by opening the start menu and locating the Java folder. Once the Java folder is located open it and click on “Configure Java”. This will open the Java control panel as seen here:
Once the control panel is open click on “About”. This will indicate what version of Java is being used as seen here:

In this case Version 7 Update 60 is being used. Therefore this version of Java would be alright. If the Version of Java is anything other than 7 accessing the meter will mostly likely not work. The update number does not matter for accessing the meter.

If Java Version 7 is not installed the user should search the internet for Version 7. Once the user locates Version 7 they should download and install this version to their computer.

**Important: Do NOT uninstall previous versions of Java until Java Version 7 has been installed.**

Once Java version 7 is installed, the user should manually go uninstall any version of Java that is greater than Version 7.
Now the user should open the Java Control Panel by clicking “Configure Java”. Next they should open click the “Security” tab. From here the user should adjust the Security Settings to “Medium” like so:

Once this is done the user should click “Apply” and then “OK” and now the user’s computer is ready to access the meter.
3.2 Wireless Access

All meters that are accessible over the Colorado State University wireless network are on a VLAN. Therefore the only way to access these meters is to access them through the University’s SSL gateway. To log in, go to https://secure.colostate.edu/meters and log in using the user’s e-id and password.

Once logged in the user should select “Start” (Red Box) to the right of the “Network Connect” option:
Once the user has entered the secure domain the user will click “Start” on the network connect and any combination of the following prompts and warnings could appear:
For any of these warnings or prompts click “Run”, “Allow”, “Continue”, and “Always”.

Once the session is opened, the user will be returned to the original home screen. Enter an IP address (List of IP Addresses on the following page) in the Browse Box and click “Browse”: 
REAL TIME METER DATA TO METRICS

<table>
<thead>
<tr>
<th>Location</th>
<th>IP address</th>
</tr>
</thead>
<tbody>
<tr>
<td>NESB</td>
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<tr>
<td>ERC B-Wing</td>
<td>10.1.252.32</td>
</tr>
<tr>
<td>District Cooling Plant #1</td>
<td>10.1.252.33</td>
</tr>
</tbody>
</table>

If this process is done correctly the following screen will appear confirming the user’s access:
3.3 Troubleshooting

- If the user is having trouble with accessing the meter wirelessly they should first check their Java security settings.

- If the user is using the proper Java version and security settings the user should then check meter access with a different browser.

- Lastly, if the user is still unable to access the meter the user can contact Chuck Sawyer:

  Chuck, Sawyer (Maintenance Engineering Technician)
  Charles.Sawyer@colostate.edu
  Cell: 970-567-1173
4 Saving Waveform Data

Once the user has access to the Eaton meter website, the last step is to save waveform data. This process is described in the following section. After reading this section, the audience will understand the capabilities of this online interface and understand how to obtain waveform information from it.

This section requires:

- Laptop/Computer
4.1 Starting Point

In this section we will start off where the last section left off. The user should understand how access to these meters is done and should be taken to the Eaton meter interface. Whether this is done with a wired or wireless connection, the initial interface will appear as the image seen below:

Next, the user will click on the ‘Meter’ button that is outlined with the red box seen above. This takes the user to the interface that is used for saving waveform data. The meter interface may be seen in the next section.
4.2 Saving Data Through Meter Interface

After clicking on the ‘Meter’ button from the initial interface, and changing the pulldown menu at the top of the page (outlined in purple) to display ‘Waveform’ the user sees the page that is seen below.

The important things to understand on this page are outlined with the three colors that are seen above. On the left hand side enclosed by the green box, the user will see the different phases. In the final revision of our program, the AutoHotkey program clicks on the BN phase then on the AN phase in order to refresh the waveform each time the program iterates.

After this, the user clicks the save button found in the orange box. This brings up a new window that allows the user to save this .csv (Excel) file in the desired location. In our program, this waveform data is saved in the same file location as a new filename based off of the iteration number. This section should give the user enough knowledge to save waveform data from the Eaton meter website after it has been accessed wirelessly or through wired connection.
5 AutoHotkey Programming

In order to automate the process of saving waveform data and uploading it through our LabVIEW program, our team used the simple macro programming method of AutoHotKey. This language has many functions but the ones that we used were those that essentially allowed the program to take over the keyboard and mouse. Instead of using code to extract data, this method allowed the program to act like it would if a human were on the other end.

It was used primarily for:

- Clicking in desired locations
- Accessing specific folders for saving and uploading waveform data
- Typing in file names
- Doing this process faster than any human could

Using AutoHotKey was an easy way for our team to solve the problem that we were assigned, to automate this process of saving and uploading waveform data. This method is not the most elegant. If your team were to look into other programming methods, our method could serve as a starting point for understanding the process.

The first step of this process is downloading AutoHotKey on any computer that is going to be used for this senior design project. This can be done at: http://www.autohotkey.com/. You may run into issues with certain functions not working as expected. This website has community forms that should answer any questions that you should have. Re-downloading from this website (http://ahkscript.org/) may also help if you are having this problem.

Once the program is installed completely on your laptop, you will have an AutoHotKey Help File. This file will answer questions about getting started and how to do certain functions of the program. It will teach you things starting with creating scripts, launching your program, sending keystrokes and mouse clicks among many other things. Because it will do a better job explaining the steps that will get you started, I will not overlap from here.

For our project, there were only a few functions that needed to be understood. These functions will be listed below:

- Establishing a hotkey
- Click function
- Sleep function
- Send function
- Loops
- Running the program
5.1 Creating an AutoHotKey file

In order to create an AutoHotKey file (after installing it to the computer being used) the user must first right click anywhere on the desktop. From here scroll to ‘New’ and then click on ‘AutoHotkey Script’. This file will appear on the desktop. After right-clicking on it and selecting ‘edit script’ the user will see a page that looks like this:

Anything that is commented out may be edited but nothing else should be.
5.2 Establishing a hotkey

Next, the user will create the hotkey. One thing that should be noted about hotkeys is that there may be as many of them in one script as needed. In the programs that our team created, there were two hotkeys. These were ‘#space’ and ‘#p’. The ‘#space’ hotkey was used in order to initiate the program while the ‘#p’ was used in order to pause the main program. In order to initiate each hotkey, the user must hold down the Windows key and either press the spacebar or the letter p. The specific notation used for creating a hotkey may be seen below in the example of our team’s code:

```
#NoEnv ; Recommended for performance and compatibility with future AutoHotkey releases.
SendMode Input ; Recommended for new scripts due to its superior speed and reliability.
SettingDir %A_ScriptDir% ; Ensures a consistent starting directory.

; #space::

Click 1132, 855 ; click on Eaton website side
Sleep, 500 ; allows for 1 second introduction
Click 42, 466 ; click on DC
Sleep, 1000 ; rest
Click 41, 452 ; clicks ‘A/B’ This resets the waveform
Sleep, 2100 ; rest
Click 858, 941 ; clicks save
Sleep, 100 ; rest
Click 200, 63 ; clicks for file location
Sleep, 880 ; rest
Send, (f) ; types f
Sleep, 300 ; rest
Click 105, 138 ; clicks for next file location
Sleep, 20 ; rest

Send, waveform\Index%d.csv [Enter] ; saves waveform as “waveform\iteration number”
Click 287, 339 ; clicks save in the second window
Click 160, 128 ; click on Labview side
Sleep, 500 ; rest
Click 71, 79 ; clicks to run waveform file
Sleep, 500 ; rest
Click 100, 400 ; click F drive
Click 100, 400 ; click F drive
Sleep, 1300 ; rest
Click 360, 228 ; click waveform captures
Sleep, 1000 ; rest
Click 386, 520 ; clicks for filename
Sleep, 500 ; rest
Send, waveform\Index%d.csv [Enter] ; accesses file just saved from Eaton website
Sleep, 1000 ; rest while waveform data runs

Return

; #p::Pause ; this hotkey toggles the above loop on and off
```

Everything between the ‘#space::’ command and ‘Return’ command is run while this file is active and the Windows key is pressed with the spacebar. Since a loop is contained within this portion of the code, it runs continuously until the Windows key and ‘p’ are pressed at the same time. The function ‘#p::Pause’ is what enables the pausing function in this program.
5.3 Using the click function

AutoHotKey also has a function that has the ability of taking over the mouse. This function is fairly simple but I will explain enough so that our code makes sense. As seen in a sample of our code below, the format that is used to execute a left click is: Click X,Y. These simple functions may be seen outlined with blue boxes.

This function is as simple as it seems. The specified X,Y coordinate on the computer screen will be left-clicked when this command comes up in a program. You may consult the AutoHotKey Help File in order to find different types of clicks. The program also has the ability to scroll.

In order to find the X and Y coordinates of the desired click location, the user must use Window Spy. This program may be found by searching ‘Window Spy’ in the Start menu. It should look similar to what is seen to the right. The coordinates of the mouse position may be found in the area that is inside the green box. Using this program, the user will be able to figure out the coordinates where clicks should be made.

When hovering over the desired click location, the user will see the x and y coordinates that should be entered into the AutoHotkey program.
5.4 Using the sleep function

The ‘Sleep’ function in AutoHotKey is a simple function. It is exactly what one would expect. The format for using this command is as follows: Sleep, (number). This number represents the number of milliseconds that the program will rest for. In our program, the rests allow the computer load time to catch up before the following click or keyboard stroke occur’s. A command of ‘Sleep, 1000’ will cause the program to rest for 1 second. An example of this function being used in our code may be seen below in the red boxes:

```
#space::
Click 1132, 855 ;Click on Eaton website side
Sleep, 500 ;allows for 1 second introduction
Click 12, 366 ;clicks 'BC'
Sleep, 1000 ;rest
Click 45, 452 ;clicks 'An' This resets the waveform
Sleep, 2300 ;rest
Click 838, 941 ;clicks save
Sleep, 500 ;rest
Click 200, 63 ;clicks for file location
Sleep, 800 ;rest
Send, t ;types f
Sleep, 500 ;rest
Click 103, 138 ;clicks for next file location
Click 105, 138 ;double click
Sleep, 500 ;rest
Click 144, 270 ;click for file name
Click 144, 270 ;click for file name
Sleep, 500 ;rest
Send, waveform0.csv {Enter} ;saves waveform as 'waveform*iteration number*'
Click 387, 339 ;clicks save in the second window
Sleep, 1700 ;rest
```
5.5 Using the send function

The next function to explain is the ‘Send’ function. This function is used in order to type keystrokes. Out of all of the previous commands mentioned, this one could be considered the most difficult to understand due to the different notations and possibilities available. Below is a screenshot of the AutoHotKey code that our team used. The purple arrows are pointing toward the lines in which the send function was used.

Both of these commands have the form that follows: ‘Send, (String)’. In the first case the letter f incased in brackets simply types the letter f. The second case types ‘Waveform0.csv’ then hits ‘Enter’. These different notations as well as any others may be explained in the AutoHotKey Help File if this guide is not satisfactory.
5.6 Loops

Using loops in AutoHotKey has many different alternatives but the one that our team used was simple. An example of the loop that our team used in our program may be seen below:

```autohotkey
Loop {
    Click 1132, 855 ; click on Eaton website side
    Sleep, 500 ; allows for 1 second introduction
    Click 41, 466 ; clicks 'DC'
    Sleep, 1000 ; rest
    Click 41, 432 ; clicks 'AB' This resets the waveform
    Sleep, 2300 ; rest
    Click 858, 941 ; clicks save
    Sleep, 500 ; rest
    Click 200, 63 ; clicks for file location
    Sleep, 800 ; rest
    Send, {f} ; types f
    Sleep, 500 ; rest
    Click 105, 138 ; clicks for next file location
    Click 105, 138 ; double click
    Sleep, 500 ; rest
    Click 144, 270 ; click for file name
    Click 144, 270 ; click for file name
    Sleep, 500 ; rest
    Send, waveform%A_Index%.csv [Enter] ; saves waveform as 'waveform%iteration number%'
    Click 387, 339 ; clicks save in the second window
    Sleep, 1700 ; rest
    Click -160, 128 ; click on LabView side
    Sleep, 500 ; rest
    Click 71, 79 ; clicks to run waveform file
    Sleep, 500 ; rest
    Click 100, 400 ; click F drive
    Click 100, 400 ; click F drive
    Sleep, 1500 ; rest
    Click 360, 228 ; click waveformcaptures
    Click 360, 228 ; click waveformcaptures
    Sleep, 1000 ; rest
    Click 387, 520 ; clicks for filename
    Sleep, 500 ; rest
    Send, waveform%A_Index%.csv [Enter] ; accesses file just saved from Eaton website
    Sleep, 1000 ; rest while waveform data runs
}
Return
#p::Pause ; this hotkey toggles the above loop on and off
```

The way the loop command in this software works is the user will start the loop by typing ‘Loop’. In the diagram above, the orange arrows point at the brackets that enclose this loop. Everything enclosed by these brackets is looped continuously. There are ways to create loops that only last a specified period of time as well as many other alternatives but I will not go into those here.
5.7 Running the program

After all of this is understood, the last step is to save and run the program. This program will only function properly if it is saved as an AutoHotKey program (notepad files will not work). Once this is ensured, the user must double click on the file. At this point an icon should pop up in the bottom right of the screen in the start bar. It will have a green AutoHotKey icon signifying that the program is running (shown with green arrow below). The process will then begin once the hotkeys are pressed. If the ‘pause’ hotkey has been pressed, the icon will appear as red (shown with red arrow below). In order to shut this program down, the user must right click the icon and exit the session.
5.8 Explaining Our Program

This section works through the specifics of the process that our program goes through. In this section the reader will gain understanding of the top level steps from beginning to the end of one iteration. For our project, the team decided that we would use an interface that has the Eaton meter website and the LabView interface side-by-side on the same screen. To keep the process the same, this resulted in the Eaton interface on the right hand side and the LabView interface on the left hand side as seen below.

After the computer is set with these two windows opened side by side, the simulation is ready to go. The user will start by double clicking on the hotkey file in order to activate it. Next, the user will press the hotkey (Windows Key + Space Bar in our case) in order to initiate the sequence. 

At this point, the program will take over control of the mouse and keyboard and begin to run the sequence of the program. The process that this program goes through may be found below numbered in order of the procession of the program

1) The program starts on the Eaton interface side where it clicks AB, BC, and then AB again. This step is used to reload the webpage to the most current waveform.

2) After the waveform is refreshed, the next click is the save button outlined in red. This button is located at the bottom-right portion of the screen. This allows the user to save the waveform at the specified file location.

3) Once the waveform is saved, the program switches sides to the LabView interface. Here the program clicks on the run button outlined in red. In this step the waveform file that was most recently saved is selected and run through the program.
This general overview gives a basic idea of what happens through one iteration of this process. The image below gives a visual representation to the three steps that are described above. Later on in section 7.1 we will discuss more of the specifics within these three steps.

Note: While this program iterates, the user should not notice any of the three metric lights displaying anything except for green. The power that these buildings receive, the waveforms that the power quality meter receives should be well within the limits of these metrics. If a user sees a red light for any of the metrics, the iteration should be immediately paused using the pause hotkey (Windows Key + p). Next, the user should access the .csv file from its saved location and look at what specifically may have set off the program.
6 Labview Programming

The majority of the Labview program that our team will pass on was developed and written by the team that came before us. Through our project, we attained access to power quality meters in order to have continuous access to waveform data. The waveform data that we found through this process is much different than the data the previous team had used. Due to the difference in sampling rates and number of periods, we had to adjust their code in order for it to work for our application.

This section of the user guide will give the user a general description of the Labview file that we inherited. Through this tutorial you will gain all of the knowledge necessary to understand and adjust the Labview program for different waveform sizes.

This section requires:

- Laptop/Computer
- Installation of NI Labview
6.1 Inputting Waveform Data
This section will address the portion of the LabVIEW code that takes in the power quality data. As seen below is the screen shot of this portion of the code:

It should be noted that this LabVIEW program runs on data from a Microsoft Excel file. However the program will only function properly with a special type of Microsoft File. All waveform data should be saved as a .CSV files (Microsoft Excel Comma Separated Values File). It should also be noted that the program is designed to run using voltage waveform data. If electrical current or any other waveform data is inputted the program will not run correctly.

In this section of the code, the LabVIEW program takes in Excel data and then displays it as an input waveform. It then senses its phase and produces an artificial perfect sine wave that the inputted waveform will be compared against for the CBEMA compliance metric. This simulated waveform is also displayed on the front panel. It should be noted that each of waveform displays have been adjusted to show waveforms of specific range of data. Therefore slight adjustments might be required to the minimum and maximum values of these graphs to properly display these waveforms.
This section of the code had to be altered in a variety of places to work with the waveform data from the power quality meters. One of these areas is the “dt” value. As seen towards the beginning of code a value is connected to the “dt” section of one of the input blocks:

Its value is 0.0001302 (Red Box). This is the value of the time difference between data points. To allow the program to function with other sets of waveform data this program will have to be changed to the corresponding time difference between data points.

The next section of code that requires slight alterations is:

The block that says “AMP. FREQ.” is a sensing block that identifies the phase of the inputted waveform and then sends that phase to the sine wave simulator. One portion of this section that requires alteration is the value of 679.8 (Red Box). This is the value of the peak voltage. It can be calculated by taking root two and multiplying by the RMS voltage.

\[ \sqrt{2} \times V_{RMS} = V_{Peak} \]
REAL TIME METER DATA TO METRICS

For our waveform data the RMS value of voltage was 480 volts. Therefore:

$$\sqrt{2} \times 480 = 678.8 \text{ Volts} \approx 679.8 \text{ Volts}$$

Therefore if different waveform was inputted then the user would have to change this value accordingly.

In addition “Simulated Signal3” (Purple Box) needs some adjustments. These adjustments can be made by double clicking this block which will open the following window:

Once the window is opened the timing settings must be changed for the inputted sets of data. The “Number of Samples” is referring to the number of samples in the Excel data set. The “Samples per second (Hz)” can be computed by taking the inverse of “dt” value.

$$\text{Samples per second (Hz)} = dt^{-1} = 0.0001302^{-1} = 7680.491551$$
6.2 Asymmetry Factor

This section of the code evaluates that inputted waveform data and computes the asymmetry factor metric according to the waveform data:

This section of code requires no changes to function with other sets of waveform data. Therefore no necessary changes are needed for the functionality of any waveform data.
6.3 Total Harmonic Distortion (THD)

In this section of code the Total Harmonic Distortion metric is computed:

This section takes the inputted waveform data and then computes the corresponding FFT values. The FFT values are then examined for the presence of harmonics.

This is the only section of the code that requires alterations from the Total Harmonic Distortion portion of the code:

Note: “71” is number indicating that the loop will monitor harmonics until the 72nd harmonic. This is done because it is the IEEE standard.

In this loop there is an algorithm (Red Box) that is specific for our set of data. This algorithm starts at index number 2 of the data and then examines every fourth data point after that. This can better be seen by examining the table of FFT values:
As seen here in the table of FFT values there exist harmonics. The first harmonic (Red Box) is at index 2. The second harmonic (Yellow Box) is four data points later at index 6. The third harmonic (Purple Box) is at index 10. As illustrated in this table we had to produce a specific algorithm to properly locate these values. Therefore for any other set of waveform data the user will have to alter this algorithm.

**Note:** To ensure that program is functioning properly the user should examine the value immediately before and after the harmonic. These values should be roughly half the value of the harmonic.
6.4 CBEMA Compliance

This section of the code evaluates the inputted waveform data and computes the CBEMA Compliance metric. It should be noted that this section of code is so large that it had to be broken into several screen shots:

![Diagram 1](image1)

![Diagram 2](image2)

![Diagram 3](image3)

This section of the code compares the inputted waveform data to the simulated waveform data and then from the results computes the CBEMA compliance metric and determines if it fails or passes.

Despite the section of this code being so large it only requires minimal changes. One of these changes can be seen below:

![Diagram 4](image4)
This screenshot is outlined in the green box above. The first value requiring alterations is 67.98 (Red Box) which is 10% of the peak voltage.

\[ 679.8 \text{ Volts} \times 0.1 = 67.98 \text{ Volts} \]

The next of these changes can be seen in the screen shot below:

This screenshot is outlined in the blue box above. The value 0.001302 (Red Box) requires changing for different data sets. This is the value of “dt”. Therefore the user should look back to Section 6.1 and determine what the “dt” value used was and then insert this value here.
7  Our AutoHotKey Program
This section of the user guide will give the user a general description of the AutoHotKey program that our team developed. Because the code is documented fairly well, most should be understood from looking at it. There are however a few things that should be pointed out in order to ensure as smooth a handoff to the next team as possible.

This section requires:

- Laptop/Computer
- AutoHotKey installed on computer
- Basic understanding of commands
7.1 Process of the Program

In section 5.8 the general process was described. This section explained the three main steps that occur in each iteration: refreshing the waveform, saving the waveform file, and running the waveform file through the LabView program. In this section the user will learn the details of this process in more detail than in section 5.8.

To start this specific program, the user begins by pressing the windows key and spacebar together. At any point, if the user intends to stop the program, they need only to press the windows key and the letter p at the same time.

After this has begun, the iterative process begins with the waveform on the Eaton interface side being refreshed. First, the mouse clicks on the Eaton interface side [1] and then on the BN button [2]. After pressing BN it clicks AN [3] and the waveform is ready to be saved. The program then goes down and clicks save at the bottom right hand side of the page [4]. The process is shown visually in the figures below. This process is best understood by reading and finding the associated red textbox that matches the description in this process.

Note: Please also note that the rest in between each click allows for the computer to catch up to the speed of the program while also waiting for loading issues associated with internet speed. We have a couple programs that each run at different speeds. The shorter the rest times, the more likely the program is to running into problems.
REAL TIME METER DATA TO METRICS

After the save button is pressed, a new window is opened up. This small window may be seen below. The program then clicks at the top of the screen where the ‘Save in:’ pulldown menu is [5] and types the letter ‘f’ [6]. The first click opens the dropdown menu which results in the second figure that is seen below. Typing the letter ‘f’ at this point is done in place of clicking on the ‘SRDESIGN’ file location. (This means that you must have your desired flash drive in the F drive as it will save here every time. This is something that may easily be changed.)
REAL TIME METER DATA TO METRICS

Once the program has gained access to the f drive, the program goes to the next window and double clicks on the ‘Waveform Capture’ file location [7]. This screen shot is not shown. After this click, the resulting window is the one seen below. As you can see, there have been many iterations of waveforms all saved here. Finally, the program clicks in the ‘File Name:’ box at the bottom of the screen [8]. This is then followed by the program taking over the keyboard and typing ‘Waveform*iteration number*’ [9]. The iteration number is of course dependent on the number of times the program has looped. After specifying the file name, the program clicks the save button in this window [10] and rests in order to allow the waveform to save.
REAL TIME METER DATA TO METRICS

At this point, all of the work on the Eaton meter interface side is done. Below you can find the AutoHotkey code with text boxes next to each command that was just illustrated by figure in order to make this make as much sense as possible. I will also include the text boxes for the LabView side in order to show the rest of the process in one place.

```autohotkey
#space::
1 -> Click 1132, 855 ;Click on Eaton website side
2 -> Click 42, 487 ;allows for 1 second introduction
3 -> Sleep, 1000 ;rest
4 -> Click 43, 472 ;clicks 'AB' This resets the waveform
5 -> Click 858, 954 ;clicks save
6 -> Sleep, 600 ;rest
7 -> Click 200, 63 ;clicks for file location
8 -> Sleep, 600 ;rest
types f
9 -> Sleep, 600 ;rest
10 -> Click 105, 138 ;clicks for next file location
11 -> Click 105, 138 ;double click
12 -> Click 144, 270 ;click for file name
13 -> Click 144, 270 ;click for file name
14 -> Sleep, 600 ;rest
15 -> Send, Waveform0.csv [Enter] ;saves waveform as 'waveform*iteration number*'
16 -> Click 387, 339 ;clicks save in the second window
17 -> Sleep, 1700 ;rest
18 -> Click -160, 128 ;Click on Labview side
19 -> Click 71, 79 ;clicks to run waveform file
20 -> Sleep, 600 ;rest
21 -> Click 100, 400 ;click F drive
22 -> Click 100, 400 ;click F drive
23 -> Sleep, 1000 ;rest
24 -> Click 360, 228 ;click waveformcaptures
25 -> Click 360, 228 ;click waveformcaptures
26 -> Sleep, 600 ;rest
27 -> Click 386, 520 ;clicks for filename
28 -> Sleep, 1000 ;rest while waveform data runs
```
After a short rest, the program clicks on the Labview side of the screen [11]. Once this has been done the program clicks on the run button at the top left of the Labview interface [12]. This opens up a window where the program will select the file to be run.
REAL TIME METER DATA TO METRICS

A figure of the run window may be seen below. After the first iteration the file is recognized and opens directly up to the 'WaveformCaptures' file. On the first iteration the program first clicks for the f drive [13] then it clicks for the ‘WaveformCaptures folder’ [14]. This is not shown here as it only happens for the first iteration. Next, the program clicks in the ‘File name:’ box [15] and types 'Waveform*iteration number*.csv' and hits the Enter button [16]. Following this command, the waveform file is run through the Labview program and assessed for the given metrics. The iteration starts all over again when the click on the Eaton interface side occurs.
7.2 Necessary Changes
At this point the process that our team went through should be understood. This section will point out the details that will need to be changed depending on the resolution of the laptop/computer screen as well as desired file locations.

Every command that uses the click function has a specified \textit{x,y} location that is part of the command. For every click command, this will need to be changed to a value that works with the specific laptop that you intend to use. If these are not changed, the program will not work at all. It requires you to be fairly specific in order to operate correctly. As explained before in section 5.3, this is done through the use of the Window Spy program that comes installed on your laptop. Since this process has been described in section 5.3, I will not go over it again here.

\textbf{Ensure that you find the correct x,y location for each click command.}

Another issue that must be addressed is the specific commands that we use in order to save these waveforms to certain file locations. Every time we ran this program we put our flash drive in the f drive. We then had to click in a certain location in order to open up the WaveformCaptures file.

When your team recreates the x,y locations for each of these clicks you must be careful to be using the x,y location that you intend. This will need to be changed in order for the program to work successfully

Another issue to be addressed is the reason for the first iteration and all of the ones that follow. In the first iteration, a few more commands are necessary on the Labview side in order to set up the file that the .csv files will be accessed from. After the first iteration, you may notice that a couple of steps are skipped in order to speed the process of running waveform files.

Lastly, we created a couple different files for our final senior design E-Days presentation:

\begin{itemize}
  \item This was the fastest file that worked effectively: FastLoop[final].ahk
  \item This file ran slower in case of slow wifi: SlowLoop[E].ahk
\end{itemize}