**Using Numerical Integration to Estimate Energy Usage**

1. Fill in the column for Power in Table 1 using the equation:

**Table 1: Calculating Energy using Numerical Integration**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Min** | **Second** | **Line1 Current (A)** | **Line2 Current (A)** | **Power (W)** | **DeltaT**  **(s)** | **Energy**  **(Ws)** |
| **0** | **47** | **1.93** | **3.72** |  |  |  |
| **0** | **53** | **1.92** | **3.72** |  |  |  |
| **0** | **58** | **1.92** | **3.72** |  |  |  |
| **1** | **4** | **1.92** | **4.99** |  |  |  |
| **1** | **9** | **1.92** | **5.02** |  |  |  |

1. Fill in the column for DeltaT by looking at the measurement time in Seconds.
2. Estimate the Energy usage over the elapsed time using the Trapezoidal Rule for numerical integration:
3. Download Current.mat. Save it in your current MATLAB directory.

5. At the MATLAB command prompt, type the command: >> load Current

1. Double click on Current in the Workspace Window to open it in the Variable Editor Window. Current is a dataset array with the following fields:

* Current.Month is a numerical vector with the month at which measurement was taken
* Current.Day is a numerical vector with the day at which measurement was taken
* Current.Year is a numerical vector with the year at which the measurement was taken
* Current.Hour is a numerical vector with the hour at which the measurement was taken
* Current.Minute is a numerical vector with the minute at which the measurement was taken
* Current.Second is a numerical vector with the second at which the measurement was taken
* Current.Line1 is a numerical vector with the current measurement on Line 1 into the house
* Current.Line2 is a numerical vector with the current measurement on Line 2 into the house

Add a column to the dataset array called Power that calculates the power based on the equation (***Do not use a for loop to do this!)***:

MATLAB Commands to add Power Column:

1. Remember that the command ***find*** is extremely useful. It works as follows:

rows = find(Condition1 & Condition 2 … )

1. Add a column to the dataset array called DeltaT that calculates the time that has elapsed between the current measurement and the previous measurement.

* Do not use a ***for*** loop to do this! It will require well over a half an hour to execute with the 1.87 million data points that we have!
* First, set Current.DeltaT(1) = 0 to create your column.
* Then use a simple vector subtraction operation followed by a correction for negative values of DeltaT. Go back to Table 1 and think about what you did to calculate DeltaT. Then think about how you handled the transition from row 3 to row 4.

MATLAB Commands to add DeltaT Column:

1. Now, add a column for Energy Usage (in W-s) using the Trapezoidal Estimate for Numerical Integration:

Again, first create the column by setting Current.Energy(1) = 0 then calculate all of the remaining values in one operation without a for loop.

MATLAB Commands to add Energy Column:

1. Take a look at Rows 10-13 of the dataset array, Current. If you have done everything correctly up to this point, the values for Power, DeltaT, and Energy should match your calculated values in Table 1. If not, find and fix your errors.
2. Use your dataset to calculate the total energy usage from July 16th through August 13th in kWh (not W.s). Use the ***find*** command to find the first measurement made on July 16th and the last measurement made on August 13th. Go from there!

MATLAB Commands:

Estimated Total Energy Usage from July 16th through August 13th:

1. Dr. Talaga’s bill from Duke Energy indicated that he used 451 kWh during this billing period. Calculate the percent error between your estimate and what Duke Power estimated as the energy usage:

% Error between Estimated Value and Duke Energy Bill:

1. Use your dataset to calculate the total energy usage from August 14th through September 12th in kWh (not W.s).

MATLAB Commands:

Estimated Total Energy Usage from August 14th through September 12th:

1. Dr. Talaga’s bill from Duke Energy indicated that he used 419 kWh during this billing period. Calculate the percent error between your estimate and what Duke Power estimated as the energy usage:

% Error between Estimated Value and Duke Energy Bill:

1. Now, that we have established that the measured data looks good, calculate and plot the ***daily*** energy usage (in kWh) during the month of August. Note: a ***for*** loop will work fine for this since you only need to loop through 31 days. Be sure to label and title your plot.

MATLAB Commands:

PLOT:

1. What days of the month look the highest for energy usage? What days of the month look the lowest for energy usage?
2. Calculate and plot the hourly energy usage (in kWh) over a single day: August 28th. Be sure to label and title your plot.

MATLAB Commands:

PLOT:

1. At what time(s) is the energy usage highest during this day? Note: smart meters typically calculate energy usage hourly then periodically transmit the hourly data to the utility company.