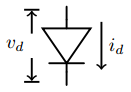
Numerical Analysis

Homework 11. Diode Networks

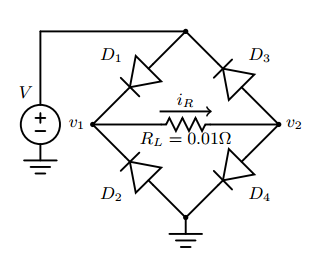
102061125 Kuan-Chun Chen

1. Objective

Diode is one of the most important elements in electronic circuits.



In this homework, I will solve the diode network below,



The equation describing the diode current as a function of diode voltage is:

,

Where is a constant known as the saturation current and

,

Is the built-in potential and is a function of temperature. For this homework, we set

Amps,

Volts.

1. Approach
   1. Problem 1.
      1. **Model the system**

Apply KCL at node and node ,

,

.

Set and then the problem becomes to find such that

,

,

,

where , and is a 2-dimensional nonlinear system problem.

Define Jacobian matrix,

.

For the 2-dimensional problem above , we have

.

Newton’s iteration is

.

It can be written as

,

.

* + 1. **Algorithm**

|  |
| --- |
| **Algorithm. Cyclic Jacobian Updates** |
| Given and a small , let  ,  ,  ,  ,  ,  ,  , |

In case that explicit Jacobian matrix is difficult to evaluate, then the Jacobian can approximate numerically

.

where is the j-th unit vector of the space and is a small increment at iteration k.

* 1. Problem 2.
     1. **Model the system**

Suppose the temperature for each diode is 300K when Volts, and it will heat up when current flows through the diode with

,

where is the current flows through the diode, is the voltage across the diode,   
and .

Apply KCL at node and node ,

,

.

For each diode temperature,

,

,

,

.

Set and then the problem becomes to find such that

,

,

,

,

,

,

,

Define Jacobian matrix,

.

Newton’s iteration is

,

.

* + 1. **Algorithm**

Same as session 2.1.2.

1. Results
   1. Voltages, currents and temperatures
      1. **Problem 1.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| V |  |  |  |  |  |  |  |
| 1 | 0.886308 | 0.113692 | 78.2617 | -1 | -1 | 78.2617 | 77.2617 |
| 0.98 | 0.866931 | 0.113069 | 76.3862 | -1 | -1 | 76.3862 | 75.3862 |
| 0.96 | 0.847568 | 0.112432 | 74.5136 | -1 | -1 | 74.5136 | 73.5136 |
| 0.94 | 0.82822 | 0.11178 | 72.6439 | -1 | -1 | 72.6439 | 71.6439 |
| 0.92 | 0.808887 | 0.111113 | 70.7774 | -1 | -1 | 70.7774 | 69.7774 |
| 0.9 | 0.789571 | 0.110429 | 68.9142 | -1 | -1 | 68.9142 | 67.9142 |
| 0.88 | 0.770272 | 0.109728 | 67.0544 | -1 | -1 | 67.0544 | 66.0544 |
| 0.86 | 0.750991 | 0.109009 | 65.1982 | -1 | -1 | 65.1982 | 64.1982 |
| 0.84 | 0.731729 | 0.108271 | 63.3458 | -1 | -1 | 63.3458 | 62.3458 |
| 0.82 | 0.712487 | 0.107513 | 61.4974 | -1 | -1 | 61.4974 | 60.4974 |
| 0.8 | 0.693266 | 0.106734 | 59.6531 | -1 | -1 | 59.6531 | 58.6531 |
| 0.78 | 0.674066 | 0.105934 | 57.8133 | -1 | -1 | 57.8133 | 56.8133 |
| 0.76 | 0.654891 | 0.105109 | 55.9781 | -1 | -1 | 55.9781 | 54.9781 |
| 0.74 | 0.63574 | 0.10426 | 54.1479 | -1 | -1 | 54.1479 | 53.1479 |
| 0.72 | 0.616614 | 0.103386 | 52.3229 | -1 | -1 | 52.3229 | 51.3229 |
| 0.7 | 0.597517 | 0.102483 | 50.5034 | -1 | -1 | 50.5034 | 49.5034 |
| 0.68 | 0.578449 | 0.101551 | 48.6898 | -1 | -1 | 48.6898 | 47.6898 |
| 0.66 | 0.559412 | 0.100588 | 46.8825 | -1 | -1 | 46.8825 | 45.8825 |
| 0.64 | 0.540409 | 0.099591 | 45.0818 | -1 | -1 | 45.0818 | 44.0818 |
| 0.62 | 0.521441 | 0.098559 | 43.2883 | -1 | -1 | 43.2883 | 42.2883 |
| 0.6 | 0.502511 | 0.097489 | 41.5023 | -1 | -1 | 41.5023 | 40.5023 |
| 0.58 | 0.483622 | 0.096378 | 39.7245 | -1 | -1 | 39.7245 | 38.7245 |
| 0.56 | 0.464777 | 0.095223 | 37.9554 | -1 | -1 | 37.9554 | 36.9554 |
| 0.54 | 0.445979 | 0.094021 | 36.1958 | -1 | -1 | 36.1958 | 35.1958 |
| 0.52 | 0.427232 | 0.092769 | 34.4463 | -1 | -1 | 34.4463 | 33.4463 |
| 0.5 | 0.408539 | 0.091461 | 32.7078 | -1 | -1 | 32.7078 | 31.7078 |
| 0.48 | 0.389906 | 0.090094 | 30.9812 | -1 | -1 | 30.9812 | 29.9812 |
| 0.46 | 0.371338 | 0.088662 | 29.2676 | -1 | -1 | 29.2676 | 28.2676 |
| 0.44 | 0.35284 | 0.08716 | 27.5681 | -1 | -1 | 27.5681 | 26.5681 |
| 0.42 | 0.33442 | 0.08558 | 25.884 | -1 | -1 | 25.884 | 24.884 |
| 0.4 | 0.316085 | 0.083915 | 24.2169 | -1 | -1 | 24.2169 | 23.2169 |
| 0.38 | 0.297842 | 0.082158 | 22.5685 | -0.99999 | -0.99999 | 22.5685 | 21.5685 |
| 0.36 | 0.279703 | 0.080297 | 20.9406 | -0.99998 | -0.99998 | 20.9406 | 19.9406 |
| 0.34 | 0.261678 | 0.078322 | 19.3356 | -0.99996 | -0.99996 | 19.3356 | 18.3357 |
| 0.32 | 0.243781 | 0.076219 | 17.756 | -0.99992 | -0.99992 | 17.756 | 16.7561 |
| 0.3 | 0.226025 | 0.073975 | 16.2048 | -0.99983 | -0.99983 | 16.2048 | 15.205 |
| 0.28 | 0.208429 | 0.071571 | 14.6855 | -0.99967 | -0.99967 | 14.6855 | 13.6858 |
| 0.26 | 0.191012 | 0.068988 | 13.2018 | -0.99936 | -0.99936 | 13.2018 | 12.2025 |
| 0.24 | 0.173799 | 0.066201 | 11.7585 | -0.99875 | -0.99875 | 11.7585 | 10.7598 |
| 0.22 | 0.156816 | 0.063184 | 10.3607 | -0.9976 | -0.9976 | 10.3607 | 9.36315 |
| 0.2 | 0.140095 | 0.059905 | 9.01447 | -0.99543 | -0.99543 | 9.01447 | 8.01904 |
| 0.18 | 0.123675 | 0.056325 | 7.72638 | -0.99141 | -0.99141 | 7.72638 | 6.73498 |
| 0.16 | 0.107599 | 0.052401 | 6.50387 | -0.98405 | -0.98405 | 6.50387 | 5.51982 |
| 0.14 | 0.09192 | 0.04808 | 5.35489 | -0.97085 | -0.97085 | 5.35489 | 4.38403 |
| 0.12 | 0.0767 | 0.0433 | 4.28768 | -0.94766 | -0.94766 | 4.28768 | 3.34002 |
| 0.1 | 0.062013 | 0.037987 | 3.31047 | -0.90792 | -0.90792 | 3.31047 | 2.40255 |
| 0.08 | 0.047946 | 0.032054 | 2.431 | -0.84183 | -0.84183 | 2.431 | 1.58917 |
| 0.06 | 0.034602 | 0.025398 | 1.65609 | -0.73574 | -0.73574 | 1.65609 | 0.920349 |
| 0.04 | 0.022093 | 0.017907 | 0.991156 | -0.57248 | -0.57248 | 0.991156 | 0.41868 |
| 0.02 | 0.010531 | 0.009469 | 0.439331 | -0.33306 | -0.33306 | 0.439331 | 0.106273 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -0.02 | -0.00947 | -0.01053 | -0.33306 | 0.439331 | 0.439331 | -0.33306 | 0.106273 |
| -0.04 | -0.01791 | -0.02209 | -0.57248 | 0.991156 | 0.991156 | -0.57248 | 0.41868 |
| -0.06 | -0.0254 | -0.0346 | -0.73574 | 1.65609 | 1.65609 | -0.73574 | 0.920349 |
| -0.08 | -0.03205 | -0.04795 | -0.84183 | 2.431 | 2.431 | -0.84183 | 1.58917 |
| -0.1 | -0.03799 | -0.06201 | -0.90792 | 3.31047 | 3.31047 | -0.90792 | 2.40255 |
| -0.12 | -0.0433 | -0.0767 | -0.94766 | 4.28768 | 4.28768 | -0.94766 | 3.34002 |
| -0.14 | -0.04808 | -0.09192 | -0.97085 | 5.35489 | 5.35489 | -0.97085 | 4.38403 |
| -0.16 | -0.0524 | -0.1076 | -0.98405 | 6.50387 | 6.50387 | -0.98405 | 5.51982 |
| -0.18 | -0.05633 | -0.12368 | -0.99141 | 7.72638 | 7.72638 | -0.99141 | 6.73498 |
| -0.2 | -0.0599 | -0.1401 | -0.99543 | 9.01447 | 9.01447 | -0.99543 | 8.01904 |
| -0.22 | -0.06318 | -0.15682 | -0.9976 | 10.3607 | 10.3607 | -0.9976 | 9.36315 |
| -0.24 | -0.0662 | -0.1738 | -0.99875 | 11.7585 | 11.7585 | -0.99875 | 10.7598 |
| -0.26 | -0.06899 | -0.19101 | -0.99936 | 13.2018 | 13.2018 | -0.99936 | 12.2025 |
| -0.28 | -0.07157 | -0.20843 | -0.99967 | 14.6855 | 14.6855 | -0.99967 | 13.6858 |
| -0.3 | -0.07398 | -0.22603 | -0.99983 | 16.2048 | 16.2048 | -0.99983 | 15.205 |
| -0.32 | -0.07622 | -0.24378 | -0.99992 | 17.756 | 17.756 | -0.99992 | 16.7561 |
| -0.34 | -0.07832 | -0.26168 | -0.99996 | 19.3356 | 19.3356 | -0.99996 | 18.3357 |
| -0.36 | -0.0803 | -0.2797 | -0.99998 | 20.9406 | 20.9406 | -0.99998 | 19.9406 |
| -0.38 | -0.08216 | -0.29784 | -0.99999 | 22.5685 | 22.5685 | -0.99999 | 21.5685 |
| -0.4 | -0.08392 | -0.31609 | -1 | 24.2169 | 24.2169 | -1 | 23.2169 |
| -0.42 | -0.08558 | -0.33442 | -1 | 25.884 | 25.884 | -1 | 24.884 |
| -0.44 | -0.08716 | -0.35284 | -1 | 27.5681 | 27.5681 | -1 | 26.5681 |
| -0.46 | -0.08866 | -0.37134 | -1 | 29.2676 | 29.2676 | -1 | 28.2676 |
| -0.48 | -0.09009 | -0.38991 | -1 | 30.9812 | 30.9812 | -1 | 29.9812 |
| -0.5 | -0.09146 | -0.40854 | -1 | 32.7078 | 32.7078 | -1 | 31.7078 |
| -0.52 | -0.09277 | -0.42723 | -1 | 34.4463 | 34.4463 | -1 | 33.4463 |
| -0.54 | -0.09402 | -0.44598 | -1 | 36.1958 | 36.1958 | -1 | 35.1958 |
| -0.56 | -0.09522 | -0.46478 | -1 | 37.9554 | 37.9554 | -1 | 36.9554 |
| -0.58 | -0.09638 | -0.48362 | -1 | 39.7245 | 39.7245 | -1 | 38.7245 |
| -0.6 | -0.09749 | -0.50251 | -1 | 41.5023 | 41.5023 | -1 | 40.5023 |
| -0.62 | -0.09856 | -0.52144 | -1 | 43.2883 | 43.2883 | -1 | 42.2883 |
| -0.64 | -0.09959 | -0.54041 | -1 | 45.0818 | 45.0818 | -1 | 44.0818 |
| -0.66 | -0.10059 | -0.55941 | -1 | 46.8825 | 46.8825 | -1 | 45.8825 |
| -0.68 | -0.10155 | -0.57845 | -1 | 48.6898 | 48.6898 | -1 | 47.6898 |
| -0.7 | -0.10248 | -0.59752 | -1 | 50.5034 | 50.5034 | -1 | 49.5034 |
| -0.72 | -0.10339 | -0.61661 | -1 | 52.3229 | 52.3229 | -1 | 51.3229 |
| -0.74 | -0.10426 | -0.63574 | -1 | 54.1479 | 54.1479 | -1 | 53.1479 |
| -0.76 | -0.10511 | -0.65489 | -1 | 55.9781 | 55.9781 | -1 | 54.9781 |
| -0.78 | -0.10593 | -0.67407 | -1 | 57.8133 | 57.8133 | -1 | 56.8133 |
| -0.8 | -0.10673 | -0.69327 | -1 | 59.6531 | 59.6531 | -1 | 58.6531 |
| -0.82 | -0.10751 | -0.71249 | -1 | 61.4974 | 61.4974 | -1 | 60.4974 |
| -0.84 | -0.10827 | -0.73173 | -1 | 63.3458 | 63.3458 | -1 | 62.3458 |
| -0.86 | -0.10901 | -0.75099 | -1 | 65.1982 | 65.1982 | -1 | 64.1982 |
| -0.88 | -0.10973 | -0.77027 | -1 | 67.0544 | 67.0544 | -1 | 66.0544 |
| -0.9 | -0.11043 | -0.78957 | -1 | 68.9142 | 68.9142 | -1 | 67.9142 |
| -0.92 | -0.11111 | -0.80889 | -1 | 70.7774 | 70.7774 | -1 | 69.7774 |
| -0.94 | -0.11178 | -0.82822 | -1 | 72.6439 | 72.6439 | -1 | 71.6439 |
| -0.96 | -0.11243 | -0.84757 | -1 | 74.5136 | 74.5136 | -1 | 73.5136 |
| -0.98 | -0.11307 | -0.86693 | -1 | 76.3862 | 76.3862 | -1 | 75.3862 |
| -1 | -0.11369 | -0.88631 | -1 | 78.2617 | 78.2617 | -1 | 77.2617 |

* + 1. **Problem 2.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| V |  |  |  |  |  |  |  |
| 1 | 0.879755 | 0.120245 | 76.9511 | -1 | -1 | 76.9511 | 75.9511 |
| 0.99 | 0.870188 | 0.119812 | 76.0377 | -1 | -1 | 76.0377 | 75.0377 |
| 0.98 | 0.860624 | 0.119376 | 75.1247 | -1 | -1 | 75.1247 | 74.1247 |
| 0.97 | 0.851062 | 0.118938 | 74.2124 | -1 | -1 | 74.2124 | 73.2124 |
| 0.96 | 0.841503 | 0.118497 | 73.3006 | -1 | -1 | 73.3006 | 72.3006 |
| 0.95 | 0.831947 | 0.118053 | 72.3893 | -1 | -1 | 72.3893 | 71.3893 |
| 0.94 | 0.822393 | 0.117607 | 71.4786 | -1 | -1 | 71.4786 | 70.4786 |
| 0.93 | 0.812843 | 0.117157 | 70.5686 | -1 | -1 | 70.5686 | 69.5686 |
| 0.92 | 0.803296 | 0.116704 | 69.6591 | -1 | -1 | 69.6591 | 68.6591 |
| 0.91 | 0.793752 | 0.116248 | 68.7503 | -1 | -1 | 68.7503 | 67.7503 |
| 0.9 | 0.784211 | 0.115789 | 67.8421 | -1 | -1 | 67.8421 | 66.8421 |
| 0.89 | 0.774673 | 0.115327 | 66.9347 | -1 | -1 | 66.9347 | 65.9347 |
| 0.88 | 0.765139 | 0.114861 | 66.0279 | -1 | -1 | 66.0279 | 65.0279 |
| 0.87 | 0.755609 | 0.114391 | 65.1218 | -1 | -1 | 65.1218 | 64.1218 |
| 0.86 | 0.746082 | 0.113918 | 64.2164 | -1 | -1 | 64.2164 | 63.2164 |
| 0.85 | 0.736559 | 0.113441 | 63.3118 | -1 | -1 | 63.3118 | 62.3118 |
| 0.84 | 0.72704 | 0.11296 | 62.408 | -1 | -1 | 62.408 | 61.408 |
| 0.83 | 0.717525 | 0.112475 | 61.505 | -1 | -1 | 61.505 | 60.505 |
| 0.82 | 0.708014 | 0.111986 | 60.6028 | -1 | -1 | 60.6028 | 59.6028 |
| 0.81 | 0.698508 | 0.111492 | 59.7015 | -1 | -1 | 59.7015 | 58.7015 |
| 0.8 | 0.689005 | 0.110995 | 58.8011 | -1 | -1 | 58.8011 | 57.8011 |
| 0.79 | 0.679508 | 0.110492 | 57.9015 | -1 | -1 | 57.9015 | 56.9015 |
| 0.78 | 0.670015 | 0.109985 | 57.0029 | -1 | -1 | 57.0029 | 56.0029 |
| 0.77 | 0.660526 | 0.109474 | 56.1053 | -1 | -1 | 56.1053 | 55.1053 |
| 0.76 | 0.651043 | 0.108957 | 55.2086 | -1 | -1 | 55.2086 | 54.2086 |
| 0.75 | 0.641565 | 0.108435 | 54.313 | -1 | -1 | 54.313 | 53.313 |
| 0.74 | 0.632092 | 0.107908 | 53.4185 | -1 | -1 | 53.4185 | 52.4185 |
| 0.73 | 0.622625 | 0.107375 | 52.525 | -1 | -1 | 52.525 | 51.525 |
| 0.72 | 0.613164 | 0.106836 | 51.6327 | -1 | -1 | 51.6327 | 50.6327 |
| 0.71 | 0.603708 | 0.106292 | 50.7416 | -1 | -1 | 50.7416 | 49.7416 |
| 0.7 | 0.594258 | 0.105742 | 49.8517 | -1 | -1 | 49.8517 | 48.8517 |
| 0.69 | 0.584815 | 0.105185 | 48.963 | -1 | -1 | 48.963 | 47.963 |
| 0.68 | 0.575378 | 0.104622 | 48.0756 | -1 | -1 | 48.0756 | 47.0756 |
| 0.67 | 0.565948 | 0.104052 | 47.1896 | -1 | -1 | 47.1896 | 46.1896 |
| 0.66 | 0.556525 | 0.103475 | 46.305 | -1 | -1 | 46.305 | 45.305 |
| 0.65 | 0.547109 | 0.102891 | 45.4218 | -1 | -1 | 45.4218 | 44.4218 |
| 0.64 | 0.537701 | 0.102299 | 44.5401 | -1 | -1 | 44.5401 | 43.5401 |
| 0.63 | 0.5283 | 0.1017 | 43.66 | -1 | -1 | 43.66 | 42.66 |
| 0.62 | 0.518907 | 0.101093 | 42.7815 | -1 | -1 | 42.7815 | 41.7815 |
| 0.61 | 0.509523 | 0.100477 | 41.9046 | -1 | -1 | 41.9046 | 40.9046 |
| 0.6 | 0.500148 | 0.099852 | 41.0295 | -1 | -1 | 41.0295 | 40.0295 |
| 0.59 | 0.490781 | 0.099219 | 40.1562 | -1 | -1 | 40.1562 | 39.1562 |
| 0.58 | 0.481424 | 0.098576 | 39.2848 | -1 | -1 | 39.2848 | 38.2848 |
| 0.57 | 0.472076 | 0.097924 | 38.4153 | -1 | -1 | 38.4153 | 37.4153 |
| 0.56 | 0.462739 | 0.097261 | 37.5478 | -1 | -1 | 37.5478 | 36.5478 |
| 0.55 | 0.453412 | 0.096588 | 36.6824 | -1 | -1 | 36.6824 | 35.6824 |
| 0.54 | 0.444096 | 0.095904 | 35.8193 | -1 | -1 | 35.8193 | 34.8193 |
| 0.53 | 0.434792 | 0.095208 | 34.9584 | -1 | -1 | 34.9584 | 33.9584 |
| 0.52 | 0.425499 | 0.094501 | 34.0999 | -1 | -1 | 34.0999 | 33.0999 |
| 0.51 | 0.416219 | 0.093781 | 33.2439 | -1 | -1 | 33.2439 | 32.2439 |
| 0.5 | 0.406952 | 0.093048 | 32.3905 | -1 | -1 | 32.3905 | 31.3905 |
| 0.49 | 0.397699 | 0.092301 | 31.5397 | -1 | -1 | 31.5397 | 30.5397 |
| 0.48 | 0.388459 | 0.091541 | 30.6919 | -1 | -1 | 30.6919 | 29.6919 |
| 0.47 | 0.379235 | 0.090765 | 29.847 | -1 | -1 | 29.847 | 28.847 |
| 0.46 | 0.370026 | 0.089974 | 29.0052 | -1 | -1 | 29.0052 | 28.0052 |
| 0.45 | 0.360833 | 0.089167 | 28.1666 | -1 | -1 | 28.1666 | 27.1666 |
| 0.44 | 0.351657 | 0.088343 | 27.3314 | -1 | -1 | 27.3314 | 26.3314 |
| 0.43 | 0.342499 | 0.087501 | 26.4999 | -1 | -1 | 26.4999 | 25.4999 |
| 0.42 | 0.33336 | 0.08664 | 25.672 | -1 | -1 | 25.672 | 24.672 |
| 0.41 | 0.324241 | 0.085759 | 24.8481 | -1 | -1 | 24.8481 | 23.8481 |
| 0.4 | 0.315142 | 0.084858 | 24.0283 | -0.99999 | -0.99999 | 24.0283 | 23.0283 |
| 0.39 | 0.306065 | 0.083935 | 23.2129 | -0.99999 | -0.99999 | 23.2129 | 22.2129 |
| 0.38 | 0.297011 | 0.08299 | 22.4021 | -0.99999 | -0.99999 | 22.4021 | 21.4021 |
| 0.37 | 0.287981 | 0.082019 | 21.5961 | -0.99998 | -0.99998 | 21.5961 | 20.5961 |
| 0.36 | 0.278976 | 0.081024 | 20.7952 | -0.99998 | -0.99998 | 20.7952 | 19.7952 |
| 0.35 | 0.269998 | 0.080002 | 19.9997 | -0.99997 | -0.99997 | 19.9997 | 18.9997 |
| 0.34 | 0.261049 | 0.078951 | 19.2098 | -0.99996 | -0.99996 | 19.2098 | 18.2099 |
| 0.33 | 0.25213 | 0.07787 | 18.426 | -0.99994 | -0.99994 | 18.426 | 17.4261 |
| 0.32 | 0.243243 | 0.076757 | 17.6485 | -0.99991 | -0.99991 | 17.6485 | 16.6486 |
| 0.31 | 0.23439 | 0.07561 | 16.8778 | -0.99988 | -0.99988 | 16.8778 | 15.8779 |
| 0.3 | 0.225572 | 0.074428 | 16.1142 | -0.99983 | -0.99983 | 16.1142 | 15.1144 |
| 0.29 | 0.216792 | 0.073208 | 15.3582 | -0.99976 | -0.99976 | 15.3582 | 14.3585 |
| 0.28 | 0.208053 | 0.071947 | 14.6103 | -0.99966 | -0.99966 | 14.6103 | 13.6106 |
| 0.27 | 0.199357 | 0.070643 | 13.8709 | -0.99953 | -0.99953 | 13.8709 | 12.8714 |
| 0.26 | 0.190707 | 0.069294 | 13.1406 | -0.99934 | -0.99934 | 13.1406 | 12.1413 |
| 0.25 | 0.182105 | 0.067895 | 12.4201 | -0.99908 | -0.99908 | 12.4201 | 11.421 |
| 0.24 | 0.173555 | 0.066445 | 11.7098 | -0.99873 | -0.99873 | 11.7098 | 10.7111 |
| 0.23 | 0.165062 | 0.064939 | 11.0105 | -0.99824 | -0.99824 | 11.0105 | 10.0123 |
| 0.22 | 0.156627 | 0.063373 | 10.323 | -0.99757 | -0.99757 | 10.323 | 9.32542 |
| 0.21 | 0.148256 | 0.061744 | 9.64791 | -0.99664 | -0.99664 | 9.64791 | 8.65126 |
| 0.2 | 0.139954 | 0.060046 | 8.98612 | -0.99538 | -0.99538 | 8.98612 | 7.99074 |
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| 0.18 | 0.123573 | 0.056427 | 7.70591 | -0.99134 | -0.99134 | 7.70591 | 6.71457 |
| 0.17 | 0.115506 | 0.054494 | 7.08935 | -0.98819 | -0.98819 | 7.08935 | 6.10115 |
| 0.16 | 0.107529 | 0.052471 | 6.48978 | -0.98396 | -0.98396 | 6.48978 | 5.50582 |
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| 0.14 | 0.091875 | 0.048125 | 5.34577 | -0.97074 | -0.97074 | 5.34577 | 4.37502 |
| 0.13 | 0.084213 | 0.045787 | 4.80341 | -0.96073 | -0.96073 | 4.80341 | 3.84268 |
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| 0.05 | 0.028235 | 0.021765 | 1.30934 | -0.66238 | -0.66238 | 1.30934 | 0.646967 |
| 0.04 | 0.022093 | 0.017907 | 0.991028 | -0.57244 | -0.57244 | 0.991028 | 0.41859 |
| 0.03 | 0.016188 | 0.013812 | 0.700984 | -0.46344 | -0.46344 | 0.700984 | 0.237546 |
| 0.02 | 0.010531 | 0.009469 | 0.439318 | -0.33305 | -0.33305 | 0.439318 | 0.106267 |
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| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| -0.01 | -0.00487 | -0.00513 | -0.17917 | 0.205841 | 0.205841 | -0.17917 | 0.026673 |
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| -0.03 | -0.01381 | -0.01619 | -0.46344 | 0.700984 | 0.700984 | -0.46344 | 0.237546 |
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| -0.05 | -0.02177 | -0.02823 | -0.66238 | 1.30934 | 1.30934 | -0.66238 | 0.646967 |
| -0.06 | -0.0254 | -0.0346 | -0.73566 | 1.65558 | 1.65558 | -0.73566 | 0.919921 |
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| -0.1 | -0.038 | -0.062 | -0.90779 | 3.30753 | 3.30753 | -0.90779 | 2.39974 |
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| -0.35 | -0.08 | -0.27 | -0.99997 | 19.9997 | 19.9997 | -0.99997 | 18.9997 |
| -0.36 | -0.08102 | -0.27898 | -0.99998 | 20.7952 | 20.7952 | -0.99998 | 19.7952 |
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| -0.4 | -0.08486 | -0.31514 | -0.99999 | 24.0283 | 24.0283 | -0.99999 | 23.0283 |
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| -0.55 | -0.09659 | -0.45341 | -1 | 36.6824 | 36.6824 | -1 | 35.6824 |
| -0.56 | -0.09726 | -0.46274 | -1 | 37.5478 | 37.5478 | -1 | 36.5478 |
| -0.57 | -0.09792 | -0.47208 | -1 | 38.4153 | 38.4153 | -1 | 37.4153 |
| -0.58 | -0.09858 | -0.48142 | -1 | 39.2848 | 39.2848 | -1 | 38.2848 |
| -0.59 | -0.09922 | -0.49078 | -1 | 40.1562 | 40.1562 | -1 | 39.1562 |
| -0.6 | -0.09985 | -0.50015 | -1 | 41.0295 | 41.0295 | -1 | 40.0295 |
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| -0.63 | -0.1017 | -0.5283 | -1 | 43.66 | 43.66 | -1 | 42.66 |
| -0.64 | -0.1023 | -0.5377 | -1 | 44.5401 | 44.5401 | -1 | 43.5401 |
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| -0.76 | -0.10896 | -0.65104 | -1 | 55.2086 | 55.2086 | -1 | 54.2086 |
| -0.77 | -0.10947 | -0.66053 | -1 | 56.1053 | 56.1053 | -1 | 55.1053 |
| -0.78 | -0.10999 | -0.67002 | -1 | 57.0029 | 57.0029 | -1 | 56.0029 |
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| -0.8 | -0.111 | -0.68901 | -1 | 58.8011 | 58.8011 | -1 | 57.8011 |
| -0.81 | -0.11149 | -0.69851 | -1 | 59.7015 | 59.7015 | -1 | 58.7015 |
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| -0.83 | -0.11248 | -0.71753 | -1 | 61.505 | 61.505 | -1 | 60.505 |
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|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| V |  |  |  |  |
| 1 | 318.506 | 301.76 | 301.76 | 318.506 |
| 0.99 | 318.22 | 301.74 | 301.74 | 318.22 |
| 0.98 | 317.936 | 301.721 | 301.721 | 317.936 |
| 0.97 | 317.653 | 301.702 | 301.702 | 317.653 |
| 0.96 | 317.372 | 301.683 | 301.683 | 317.372 |
| 0.95 | 317.092 | 301.664 | 301.664 | 317.092 |
| 0.94 | 316.813 | 301.645 | 301.645 | 316.813 |
| 0.93 | 316.535 | 301.626 | 301.626 | 316.535 |
| 0.92 | 316.259 | 301.607 | 301.607 | 316.259 |
| 0.91 | 315.984 | 301.588 | 301.588 | 315.984 |
| 0.9 | 315.711 | 301.568 | 301.568 | 315.711 |
| 0.89 | 315.439 | 301.549 | 301.549 | 315.439 |
| 0.88 | 315.168 | 301.53 | 301.53 | 315.168 |
| 0.87 | 314.899 | 301.511 | 301.511 | 314.899 |
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| 0.84 | 314.099 | 301.454 | 301.454 | 314.099 |
| 0.83 | 313.836 | 301.435 | 301.435 | 313.836 |
| 0.82 | 313.573 | 301.416 | 301.416 | 313.573 |
| 0.81 | 313.313 | 301.397 | 301.397 | 313.313 |
| 0.8 | 313.053 | 301.378 | 301.378 | 313.053 |
| 0.79 | 312.795 | 301.359 | 301.359 | 312.795 |
| 0.78 | 312.539 | 301.34 | 301.34 | 312.539 |
| 0.77 | 312.284 | 301.321 | 301.321 | 312.284 |
| 0.76 | 312.031 | 301.302 | 301.302 | 312.031 |
| 0.75 | 311.779 | 301.283 | 301.283 | 311.779 |
| 0.74 | 311.529 | 301.264 | 301.264 | 311.529 |
| 0.73 | 311.28 | 301.245 | 301.245 | 311.28 |
| 0.72 | 311.033 | 301.226 | 301.226 | 311.033 |
| 0.71 | 310.787 | 301.207 | 301.207 | 310.787 |
| 0.7 | 310.543 | 301.189 | 301.189 | 310.543 |
| 0.69 | 310.3 | 301.17 | 301.17 | 310.3 |
| 0.68 | 310.06 | 301.151 | 301.151 | 310.06 |
| 0.67 | 309.82 | 301.132 | 301.132 | 309.82 |
| 0.66 | 309.583 | 301.113 | 301.113 | 309.583 |
| 0.65 | 309.347 | 301.094 | 301.094 | 309.347 |
| 0.64 | 309.113 | 301.075 | 301.075 | 309.113 |
| 0.63 | 308.88 | 301.057 | 301.057 | 308.88 |
| 0.62 | 308.65 | 301.038 | 301.038 | 308.65 |
| 0.61 | 308.421 | 301.019 | 301.019 | 308.421 |
| 0.6 | 308.194 | 301 | 301 | 308.194 |
| 0.59 | 307.969 | 300.982 | 300.982 | 307.969 |
| 0.58 | 307.745 | 300.963 | 300.963 | 307.745 |
| 0.57 | 307.524 | 300.944 | 300.944 | 307.524 |
| 0.56 | 307.304 | 300.925 | 300.925 | 307.304 |
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| 0.52 | 306.445 | 300.851 | 300.851 | 306.445 |
| 0.51 | 306.235 | 300.832 | 300.832 | 306.235 |
| 0.5 | 306.028 | 300.814 | 300.814 | 306.028 |
| 0.49 | 305.822 | 300.795 | 300.795 | 305.822 |
| 0.48 | 305.619 | 300.777 | 300.777 | 305.619 |
| 0.47 | 305.418 | 300.758 | 300.758 | 305.418 |
| 0.46 | 305.219 | 300.74 | 300.74 | 305.219 |
| 0.45 | 305.023 | 300.722 | 300.722 | 305.023 |
| 0.44 | 304.829 | 300.703 | 300.703 | 304.829 |
| 0.43 | 304.638 | 300.685 | 300.685 | 304.638 |
| 0.42 | 304.448 | 300.667 | 300.667 | 304.448 |
| 0.41 | 304.262 | 300.648 | 300.648 | 304.262 |
| 0.4 | 304.078 | 300.63 | 300.63 | 304.078 |
| 0.39 | 303.897 | 300.612 | 300.612 | 303.897 |
| 0.38 | 303.718 | 300.594 | 300.594 | 303.718 |
| 0.37 | 303.543 | 300.576 | 300.576 | 303.543 |
| 0.36 | 303.37 | 300.558 | 300.558 | 303.37 |
| 0.35 | 303.2 | 300.54 | 300.54 | 303.2 |
| 0.34 | 303.033 | 300.522 | 300.522 | 303.033 |
| 0.33 | 302.87 | 300.504 | 300.504 | 302.87 |
| 0.32 | 302.709 | 300.486 | 300.486 | 302.709 |
| 0.31 | 302.552 | 300.469 | 300.469 | 302.552 |
| 0.3 | 302.399 | 300.451 | 300.451 | 302.399 |
| 0.29 | 302.249 | 300.433 | 300.433 | 302.249 |
| 0.28 | 302.102 | 300.416 | 300.416 | 302.102 |
| 0.27 | 301.96 | 300.399 | 300.399 | 301.96 |
| 0.26 | 301.821 | 300.381 | 300.381 | 301.821 |
| 0.25 | 301.687 | 300.364 | 300.364 | 301.687 |
| 0.24 | 301.556 | 300.347 | 300.347 | 301.556 |
| 0.23 | 301.43 | 300.33 | 300.33 | 301.43 |
| 0.22 | 301.308 | 300.312 | 300.312 | 301.308 |
| 0.21 | 301.191 | 300.296 | 300.296 | 301.191 |
| 0.2 | 301.079 | 300.279 | 300.279 | 301.079 |
| 0.19 | 300.972 | 300.262 | 300.262 | 300.972 |
| 0.18 | 300.87 | 300.245 | 300.245 | 300.87 |
| 0.17 | 300.773 | 300.228 | 300.228 | 300.773 |
| 0.16 | 300.681 | 300.212 | 300.212 | 300.681 |
| 0.15 | 300.595 | 300.195 | 300.195 | 300.595 |
| 0.14 | 300.515 | 300.178 | 300.178 | 300.515 |
| 0.13 | 300.44 | 300.162 | 300.162 | 300.44 |
| 0.12 | 300.371 | 300.145 | 300.145 | 300.371 |
| 0.11 | 300.308 | 300.129 | 300.129 | 300.308 |
| 0.1 | 300.251 | 300.113 | 300.113 | 300.251 |
| 0.09 | 300.201 | 300.096 | 300.096 | 300.201 |
| 0.08 | 300.156 | 300.081 | 300.081 | 300.156 |
| 0.07 | 300.117 | 300.065 | 300.065 | 300.117 |
| 0.06 | 300.084 | 300.051 | 300.051 | 300.084 |
| 0.05 | 300.057 | 300.037 | 300.037 | 300.057 |
| 0.04 | 300.035 | 300.025 | 300.025 | 300.035 |
| 0.03 | 300.019 | 300.015 | 300.015 | 300.019 |
| 0.02 | 300.008 | 300.007 | 300.007 | 300.008 |
| 0.01 | 300.002 | 300.002 | 300.002 | 300.002 |
| 0 | 300 | 300 | 300 | 300 |
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| -0.13 | 300.162 | 300.44 | 300.44 | 300.162 |
| -0.14 | 300.178 | 300.515 | 300.515 | 300.178 |
| -0.15 | 300.195 | 300.595 | 300.595 | 300.195 |
| -0.16 | 300.212 | 300.681 | 300.681 | 300.212 |
| -0.17 | 300.228 | 300.773 | 300.773 | 300.228 |
| -0.18 | 300.245 | 300.87 | 300.87 | 300.245 |
| -0.19 | 300.262 | 300.972 | 300.972 | 300.262 |
| -0.2 | 300.279 | 301.079 | 301.079 | 300.279 |
| -0.21 | 300.296 | 301.191 | 301.191 | 300.296 |
| -0.22 | 300.312 | 301.308 | 301.308 | 300.312 |
| -0.23 | 300.33 | 301.43 | 301.43 | 300.33 |
| -0.24 | 300.347 | 301.556 | 301.556 | 300.347 |
| -0.25 | 300.364 | 301.687 | 301.687 | 300.364 |
| -0.26 | 300.381 | 301.821 | 301.821 | 300.381 |
| -0.27 | 300.399 | 301.96 | 301.96 | 300.399 |
| -0.28 | 300.416 | 302.102 | 302.102 | 300.416 |
| -0.29 | 300.433 | 302.249 | 302.249 | 300.433 |
| -0.3 | 300.451 | 302.399 | 302.399 | 300.451 |
| -0.31 | 300.469 | 302.552 | 302.552 | 300.469 |
| -0.32 | 300.486 | 302.709 | 302.709 | 300.486 |
| -0.33 | 300.504 | 302.87 | 302.87 | 300.504 |
| -0.34 | 300.522 | 303.033 | 303.033 | 300.522 |
| -0.35 | 300.54 | 303.2 | 303.2 | 300.54 |
| -0.36 | 300.558 | 303.37 | 303.37 | 300.558 |
| -0.37 | 300.576 | 303.543 | 303.543 | 300.576 |
| -0.38 | 300.594 | 303.718 | 303.718 | 300.594 |
| -0.39 | 300.612 | 303.897 | 303.897 | 300.612 |
| -0.4 | 300.63 | 304.078 | 304.078 | 300.63 |
| -0.41 | 300.648 | 304.262 | 304.262 | 300.648 |
| -0.42 | 300.667 | 304.448 | 304.448 | 300.667 |
| -0.43 | 300.685 | 304.638 | 304.638 | 300.685 |
| -0.44 | 300.703 | 304.829 | 304.829 | 300.703 |
| -0.45 | 300.722 | 305.023 | 305.023 | 300.722 |
| -0.46 | 300.74 | 305.219 | 305.219 | 300.74 |
| -0.47 | 300.758 | 305.418 | 305.418 | 300.758 |
| -0.48 | 300.777 | 305.619 | 305.619 | 300.777 |
| -0.49 | 300.795 | 305.822 | 305.822 | 300.795 |
| -0.5 | 300.814 | 306.028 | 306.028 | 300.814 |
| -0.51 | 300.832 | 306.235 | 306.235 | 300.832 |
| -0.52 | 300.851 | 306.445 | 306.445 | 300.851 |
| -0.53 | 300.87 | 306.657 | 306.657 | 300.87 |
| -0.54 | 300.888 | 306.87 | 306.87 | 300.888 |
| -0.55 | 300.907 | 307.086 | 307.086 | 300.907 |
| -0.56 | 300.925 | 307.304 | 307.304 | 300.925 |
| -0.57 | 300.944 | 307.524 | 307.524 | 300.944 |
| -0.58 | 300.963 | 307.745 | 307.745 | 300.963 |
| -0.59 | 300.982 | 307.969 | 307.969 | 300.982 |
| -0.6 | 301 | 308.194 | 308.194 | 301 |
| -0.61 | 301.019 | 308.421 | 308.421 | 301.019 |
| -0.62 | 301.038 | 308.65 | 308.65 | 301.038 |
| -0.63 | 301.057 | 308.88 | 308.88 | 301.057 |
| -0.64 | 301.075 | 309.113 | 309.113 | 301.075 |
| -0.65 | 301.094 | 309.347 | 309.347 | 301.094 |
| -0.66 | 301.113 | 309.583 | 309.583 | 301.113 |
| -0.67 | 301.132 | 309.82 | 309.82 | 301.132 |
| -0.68 | 301.151 | 310.06 | 310.06 | 301.151 |
| -0.69 | 301.17 | 310.3 | 310.3 | 301.17 |
| -0.7 | 301.189 | 310.543 | 310.543 | 301.189 |
| -0.71 | 301.207 | 310.787 | 310.787 | 301.207 |
| -0.72 | 301.226 | 311.033 | 311.033 | 301.226 |
| -0.73 | 301.245 | 311.28 | 311.28 | 301.245 |
| -0.74 | 301.264 | 311.529 | 311.529 | 301.264 |
| -0.75 | 301.283 | 311.779 | 311.779 | 301.283 |
| -0.76 | 301.302 | 312.031 | 312.031 | 301.302 |
| -0.77 | 301.321 | 312.284 | 312.284 | 301.321 |
| -0.78 | 301.34 | 312.539 | 312.539 | 301.34 |
| -0.79 | 301.359 | 312.795 | 312.795 | 301.359 |
| -0.8 | 301.378 | 313.053 | 313.053 | 301.378 |
| -0.81 | 301.397 | 313.313 | 313.313 | 301.397 |
| -0.82 | 301.416 | 313.573 | 313.573 | 301.416 |
| -0.83 | 301.435 | 313.836 | 313.836 | 301.435 |
| -0.84 | 301.454 | 314.099 | 314.099 | 301.454 |
| -0.85 | 301.473 | 314.364 | 314.364 | 301.473 |
| -0.86 | 301.492 | 314.631 | 314.631 | 301.492 |
| -0.87 | 301.511 | 314.899 | 314.899 | 301.511 |
| -0.88 | 301.53 | 315.168 | 315.168 | 301.53 |
| -0.89 | 301.549 | 315.439 | 315.439 | 301.549 |
| -0.9 | 301.568 | 315.711 | 315.711 | 301.568 |
| -0.91 | 301.588 | 315.984 | 315.984 | 301.588 |
| -0.92 | 301.607 | 316.259 | 316.259 | 301.607 |
| -0.93 | 301.626 | 316.535 | 316.535 | 301.626 |
| -0.94 | 301.645 | 316.813 | 316.813 | 301.645 |
| -0.95 | 301.664 | 317.092 | 317.092 | 301.664 |
| -0.96 | 301.683 | 317.372 | 317.372 | 301.683 |
| -0.97 | 301.702 | 317.653 | 317.653 | 301.702 |
| -0.98 | 301.721 | 317.936 | 317.936 | 301.721 |
| -0.99 | 301.74 | 318.22 | 318.22 | 301.74 |
| -1 | 301.76 | 318.506 | 318.506 | 301.76 |

* 1. Plot
     1. **Problem 1.**
* **Voltages**
* **Currents**
  + 1. **Problem 2.**
* **Voltages**
* **Currents**
* **Temperature**

1. Observations

* Both problem 1 and problem 2
  + The voltage of node and node have opposite trends.
  + The current and the temperature of diode 1 and diode 4 have same trends;   
    the current and the temperature of diode 2 and diode 3 have same trends.  
    The former and the latter have opposite trends.
  + The current trend of is symmetric.