Appendix A: Network Data for the IEEE 118-bus System

This appendix contains the network data for the IEEE 118-bus test network used in the Wheatstone analysis of Chapter 6. The data was downloaded from the IEEE power systems test case archive at [www.ee.washington.edu/research/pstca/.](http://www.ee.washington.edu/research/pstca/) The data is given in a format consistent with Matpower, a free set of Matlab files for power system simulation and analysis, available at [http://www.pserc.corne11.edu/matpower/.](http://www.pserc.corne11.edu/matpower/)

**Al. Bus and Demand Data**

Bus and demand data for the 118-bus test network is given in Table Al. The variables and units used in the column headings of Table Al are:

*Pz:* Real power demand, in [MW]

*Qz:* Reactive power demand, in [MVar]

Bus voltage magnitude, in per-unit for a voltage base of 100 kV f Bus voltage angle, in degrees

*Vmax:* Maximum bus voltage magnitude, in per-unit for a voltage base of 100 kV

***Vmin:*** Maximum bus voltage magnitude, in per-unit for a voltage base of 100 kV

249

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bus | L | Q | V | 8 | Vmax | Vmin |
| 1 | 51 | 27 | 0.955 | 10.983 | 1.06 | 0.94 |
| 2 | 20 | 9 | 0.97139 | 11.523 | 1.06 | 0.94 |
| 3 | 39 | 10 | 0.96769 | 11.866 | 1.06 | 0.94 |
| 4 | 39 | 12 | 0.998 | 15.583 | 1.06 | 0.94 |
| 5 | 0 | 0 | 1.00198 | 16.028 | 1.06 | 0.94 |
| 6 | 52 | 22 | 0.99 | 13.302 | 1.06 | 0.94 |
| 7 | 19 | 2 | 0.98933 | 12.857 | 1.06 | 0.94 |
| 8 | 28 | 0 | 1.015 | 21.049 | 1.06 | 0.94 |
| 9 | 0 | 0 | 1.04292 | 28.303 | 1.06 | 0.94 |
| 10 | 0 | 0 | 1.05 | 35.884 | 1.06 | 0.94 |
| 11 | 70 | 23 | 0.98509 | 13.016 | 1.06 | 0.94 |
| 12 | 47 | 10 | 0.99 | 12.499 | 1.06 | 0.94 |
| 13 | 34 | 16 | 0.9683 | 11.641 | 1.06 | 0.94 |
| 14 | 14 | 1 | 0.98359 | 11.783 | 1.06 | 0.94 |
| 15 | 90 | 30 | 0.97 | 11.489 | 1.06 | 0.94 |
| 16 | 25 | 10 | 0.98391 | 12.198 | 1.06 | 0.94 |
| 17 | 11 | 3 | 0.99513 | 14.006 | 1.06 | 0.94 |
| 18 | 60 | 34 | 0.973 | 11.793 | 1.06 | 0.94 |
| 19 | 45 | 25 | 0.963 | 11.314 | 1.06 | 0.94 |
| 20 | 18 | 3 | 0.95776 | 12.192 | 1.06 | 0.94 |
| 21 | 14 | 8 | 0.95841 | 13.779 | 1.06 | 0.94 |
| 22 | 10 | 5 | 0.96954 | 16.332 | 1.06 | 0.94 |
| 23 | 7 | 3 | 0.99972 | 21.249 | 1.06 | 0.94 |
| 24 | 13 | 0 | 0.992 | 21.118 | 1.06 | 0.94 |
| 25 | 0 | 0 | 1.05 | 28.184 | 1.06 | 0.94 |
| 26 | 0 | 0 | 1.015 | 29.965 | 1.06 | 0.94 |
| 27 | 71 | 13 | 0.968 | 15.613 | 1.06 | 0.94 |
| 28 | 17 | 7 | 0.96157 | 13.889 | 1.06 | 0.94 |
| 29 | 24 | 4 | 0.96322 | 12.897 | 1.06 | 0.94 |
| 30 | 0 | 0 | 0.98553 | 19.04 | 1.06 | 0.94 |
| 31 | 43 | 27 | 0.967 | 13.014 | 1.06 | 0.94 |
| 32 | 59 | 23 | 0.964 | 15.054 | 1.06 | 0.94 |
| 33 | 23 | 9 | 0.97161 | 10.864 | 1.06 | 0.94 |
| 34 | 59 | 26 | 0.986 | 11.505 | 1.06 | 0.94 |
| 35 | 33 | 9 | 0.9807 | 11.08 | 1.06 | 0.94 |
| 36 | 31 | 17 | 0.98 | 11.085 | 1.06 | 0.94 |
| 37 | 0 | 0 | 0.99208 | 11.969 | 1.06 | 0.94 |
| 38 | 0 | 0 | 0.96204 | 17.106 | 1.06 | 0.94 |

*Table AI. Bus data for the IEEE 118-bus network*

250

*Table AI (continued)*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bus | L | ML | V | B | Vmax | Vmin |
| 39 | 27 | 11 | 0.97049 | 8.598 | 1.06 | 0.94 |
| 40 | 66 | 23 | 0.97 | 7.525 | 1.06 | 0.94 |
| 41 | 37 | 10 | 0.96683 | 7.079 | 1.06 | 0.94 |
| 42 | 96 | 23 | 0.985 | 8.674 | 1.06 | 0.94 |
| 43 | 18 | 7 | 0.97858 | 11.459 | 1.06 | 0.94 |
| 44 | 16 | 8 | 0.98505 | 13.945 | 1.06 | 0.94 |
| 45 | 53 | 22 | 0.98667 | 15.776 | 1.06 | 0.94 |
| 46 | 28 | 10 | 1.005 | 18.582 | 1.06 | 0.94 |
| 47 | 34 | 0 | 1.01705 | 20.805 | 1.06 | 0.94 |
| 48 | 20 | 11 | 1.02063 | 20.025 | 1.06 | 0.94 |
| 49 | 87 | 30 | 1.025 | 21.028 | 1.06 | 0.94 |
| 50 | 17 | 4 | 1.00108 | 18.989 | 1.06 | 0.94 |
| 51 | 17 | 8 | 0.96688 | 16.37 | 1.06 | 0.94 |
| 52 | 18 | 5 | 0.95682 | 15.417 | 1.06 | 0.94 |
| 53 | 23 | 11 | 0.94598 | 14.442 | 1.06 | 0.94 |
| 54 | 113 | 32 | 0.955 | 15.353 | 1.06 | 0.94 |
| 55 | 63 | 22 | 0.952 | 15.063 | 1.06 | 0.94 |
| 56 | 84 | 18 | 0.954 | 15.25 | 1.06 | 0.94 |
| 57 | 12 | 3 | 0.97058 | 16.455 | 1.06 | 0.94 |
| 58 | 12 | 3 | 0.95904 | 15.598 | 1.06 | 0.94 |
| 59 | 277 | 113 | 0.985 | 19.452 | 1.06 | 0.94 |
| 60 | 78 | 3 | 0.99316 | 23.234 | 1.06 | 0.94 |
| 61 | 0 | 0 | 0.995 | 24.125 | 1.06 | 0.94 |
| 62 | 77 | 14 | 0.998 | 23.509 | 1.06 | 0.94 |
| 63 | 0 | 0 | 0.96874 | 22.831 | 1.06 | 0.94 |
| 64 | 0 | 0 | 0.98374 | 24.597 | 1.06 | 0.94 |
| 65 | 0 | 0 | 1.005 | 27.722 | 1.06 | 0.94 |
| 66 | 39 | 18 | 1.05 | 27.563 | 1.06 | 0.94 |
| 67 | 28 | 7 | 1.01968 | 24.923 | 1.06 | 0.94 |
| 68 | 0 | 0 | 1.00325 | 27.601 | 1.06 | 0.94 |
| 69 | 0 | 0 | 1.035 | 30 | 1.06 | 0.94 |
| 70 | 66 | 20 | 0.984 | 22.62 | 1.06 | 0.94 |
| 71 | 0 | 0 | 0.98684 | 22.209 | 1.06 | 0.94 |
| 72 | 12 | 0 | 0.98 | 21.112 | 1.06 | 0.94 |
| 73 | 6 | 0 | 0.991 | 21.998 | 1.06 | 0.94 |
| 74 | 68 | 27 | 0.958 | 21.671 | 1.06 | 0.94 |
| 75 | 47 | 11 | 0.96733 | 22.933 | 1.06 | 0.94 |
| 76 | 68 | 36 | 0.943 | 21.803 | 1.06 | 0.94 |
| 77 | 61 | 28 | 1.006 | 26.757 | 1.06 | 0.94 |
| 78 | 71 | 26 | 1.00342 | 26.453 | 1.06 | 0.94 |

251

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Bus |  | ML | V | 8 | Vmax | Vmin |
| 79 | 39 | 32 | 1.00922 | 26.752 | 1.06 | 0.94 |
| 80 | 130 | 26 | 1.04 | 28.998 | 1.06 | 0.94 |
| 81 | 0 | 0 | 0.99681 | 28.149 | 1.06 | 0.94 |
| 82 | 54 | 27 | 0.98881 | 27.276 | 1.06 | 0.94 |
| 83 | 20 | 10 | 0.98457 | 28.465 | 1.06 | 0.94 |
| 84 | 11 | 7 | 0.97977 | 30.997 | 1.06 | 0.94 |
| 85 | 24 | 15 | 0.985 | 32.55 | 1.06 | 0.94 |
| 86 | 21 | 10 | 0.98669 | 31.181 | 1.06 | 0.94 |
| 87 | 0 | 0 | 1.015 | 31.44 | 1.06 | 0.94 |
| 88 | 48 | 10 | 0.98746 | 35.68 | 1.06 | 0.94 |
| 89 | 0 | 0 | 1.005 | 39.734 | 1.06 | 0.94 |
| 90 | 440 | 42 | 0.985 | 33.331 | 1.06 | 0.94 |
| 91 | 10 | 0 | 0.98 | 33.352 | 1.06 | 0.94 |
| 92 | 65 | 10 | 0.993 | 33.841 | 1.06 | 0.94 |
| 93 | 12 | 7 | 0.98737 | 30.837 | 1.06 | 0.94 |
| 94 | 30 | 16 | 0.99081 | 28.687 | 1.06 | 0.94 |
| 95 | 42 | 31 | 0.98lll | 27.716 | 1.06 | 0.94 |
| 96 | 38 | 15 | 0.9928 | 27.549 | 1.06 | 0.94 |
| 97 | 15 | 9 | 1.01143 | 27.923 | 1.06 | 0.94 |
| 98 | 34 | 8 | 1.02351 | 27.446 | 1.06 | 0.94 |
| 99 | 42 | 0 | 1.01 | 27.085 | 1.06 | 0.94 |
| 100 | 37 | 18 | 1.017 | 28.081 | 1.06 | 0.94 |
| 101 | 22 | 15 | 0.99276 | 29.649 | 1.06 | 0.94 |
| 102 | 5 | 3 | 0.99159 | 32.341 | 1.06 | 0.94 |
| 103 | 23 | 16 | 1.001 | 24.48 | 1.06 | 0.94 |
| 104 | 38 | 25 | 0.971 | 21.742 | 1.06 | 0.94 |
| 105 | 31 | 26 | 0.965 | 20.634 | 1.06 | 0.94 |
| 106 | 43 | 16 | 0.96114 | 20.379 | 1.06 | 0.94 |
| 107 | 50 | 12 | 0.952 | 17.576 | 1.06 | 0.94 |
| 108 | 2 | 1 | 0.96621 | 19.434 | 1.06 | 0.94 |
| 109 | 8 | 3 | 0.96703 | 18.982 | 1.06 | 0.94 |
| 110 | 39 | 30 | 0.973 | 18.135 | 1.06 | 0.94 |
| 111 | 0 | 0 | 0.98 | 19.78 | 1.06 | 0.94 |
| 112 | 68 | 13 | 0.975 | 15.036 | 1.06 | 0.94 |
| 113 | 6 | 0 | 0.993 | 14.004 | 1.06 | 0.94 |
| 114 | 8 | 3 | 0.96068 | 14.727 | 1.06 | 0.94 |
| 115 | 22 | 7 | 0.96053 | 14.72 | 1.06 | 0.94 |
| 116 | 184 | 0 | 1.005 | 27.166 | 1.06 | 0.94 |
| 117 | 20 | 8 | 0.97382 | 10.958 | 1.06 | 0.94 |
| 118 | 33 | 15 | 0.94944 | 21.945 | 1.06 | 0.94 |

*Table AI (continued)*

252

A2. Generator Data

Generator data for the IEEE 118-bus test network is shown in Table A2. The variables and units used in the column headings of Table A2 are:

*Pz:* Real power output, in [MW]

*Qc-’* Reactive power output, in [MVar]

*Qc, :* Maximum reactive power output, in [MVar]

*Qc. : :* Minimum reactive power output, in [MVar]

K: Voltage magnitude setpoint, in per-unit for a base voltage of 100 kV.

*c,+z:* Maximum real power output, in [MW]

*c,+iz:* Minimum real power output, in [MW]

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Bus | G | VG | QG,max | QG,min | V | G,max | **G,min** |
| 10 | 450 | -51.04 | 200 | -147 | 1.05 | 550 | 0 |
| 12 | 85 | 91.27 | 120 | -35 | 0.99 | 185 | 0 |
| 25 | 220 | 49.72 | 140 | -47 | 1.05 | 320 | 0 |
| 26 | 314 | 9.89 | 1000 | -1000 | 1.015 | 414 | 0 |
| 31 | 7 | 31.57 | 300 | -300 | 0.967 | 107 | 0 |
| 46 | 19 | -5.25 | 100 | -100 | 1.005 | 119 | 0 |
| 49 | 204 | 115.63 | 210 | -85 | 1.025 | 304 | 0 |
| 54 | 48 | 3.9 | 300 | -300 | 0.955 | 148 | 0 |
| 59 | 155 | 76.83 | 180 | -60 | 0.985 | 255 | 0 |
| 61 | 160 | -40.39 | 300 | -100 | 0.995 | 260 | 0 |
| 65 | 391 | 80.76 | 200 | -67 | 1.005 | 491 | 0 |
| 66 | 392 | -1.95 | 200 | -67 | 1.05 | 492 | 0 |
| 69 | 513.48 | -82.39 | 300 | -300 | 1.035 | 805.2 | 0 |
| 80 | 477 | 104.9 | 280 | -165 | 1.04 | 577 | 0 |
| 87 | 4 | 11.02 | 1000 | -100 | 1.015 | 104 | 0 |
| 92 | 607 | 0.49 | 9 | -3 | 0.99 | 100 | 0 |
| 100 | 252 | 108.87 | 155 | -50 | 1.017 | 352 | 0 |
| 103 | 40 | 41.69 | 40 | -15 | 1.01 | 140 | 0 |
| 111 | 36 | -1.84 | 1000 | -100 | 0.98 | 136 | 0 |

*Table A2: Generator data for the* ***IEEE*** *118-bus network*

253

A3. Branch Data

Branch data for the IEEE 118-bus test network are shown in Table A3. The variables and

units used in the column headings of Table A3 are:

*From:* Identifies the bus number of one end of the branch *To:* Identifies the bus number of the other end of the branch fi: Resistance, in per-unit for a base voltage of 100 kV

Reactance, in per-unit for a base voltage of 100 kV

*B:* Line charging susceptance, in per-unit for a base voltage of 100 kV

*RateA:* Long-term or stability limit of the line, in [MVA]

*RateB:* Short-term limit of the line, in [MVA]

*RateC:* Emergency limit of the line, in [MVA]

Users of this data should note that the susceptances used in the DC power flows in this

thesis were calculated directly from the line reactances I, according to the formula:

(Al) *B, ——*

1

*i — j*



1

0 I, =0.

254

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| From | TS | R | X | B | RateA | RateB | RateC |
| 1 | 2 | 0.0303 | 0.0999 | 0.0254 | 220 | 230 | 250 |
| 1 | 3 | 0.0129 | 0.0424 | 0.01082 | 220 | 230 | 250 |
| 2 | 12 | 0.0187 | 0.0616 | 0.01572 | 220 | 230 | 250 |
| 3 | 5 | 0.0241 | 0.108 | 0.0284 | 220 | 230 | 250 |
| 3 | 12 | 0.0484 | 0.16 | 0.0406 | 220 | 230 | 250 |
| 4 | 5 | 0.00176 | 0.00798 | 0.0021 | 440 | 460 | 500 |
| 4 | 11 | 0.0209 | 0.0688 | 0.01748 | 220 | 230 | 250 |
| 5 | 6 | 0.0119 | 0.054 | 0.01426 | 220 | 230 | 250 |
| 5 | 11 | 0.0203 | 0.0682 | 0.01738 | 220 | 230 | 250 |
| 6 | 7 | 0.00459 | 0.0208 | 0.0055 | 220 | 230 | 250 |
| 7 | 12 | 0.00862 | 0.034 | 0.00874 | 220 | 230 | 250 |
| 8 | 9 | 0.00244 | 0.0305 | 1.162 | 1100 | 1150 | 1250 |
| 8 | 5 | 0 | 0.0267 | 0 | 880 | 920 | 1000 |
| 8 | 30 | 0.00431 | 0.0504 | 0.514 | 220 | 230 | 250 |
| 9 | 10 | 0.00258 | 0.0322 | 1.23 | 1100 | 1150 | 1250 |
| 11 | 12 | 0.00595 | 0.0196 | 0.00502 | 220 | 230 | 250 |
| 11 | 13 | 0.02225 | 0.0731 | 0.01876 | 220 | 230 | 250 |
| 12 | 15 | 0.0215 | 0.0707 | 0.01816 | 220 | 230 | 250 |
| 12 | 17 | 0.0212 | 0.0834 | 0.0214 | 220 | 230 | 250 |
| 12 | 117 | 0.0329 | 0.14 | 0.0358 | 220 | 230 | 250 |
| 13 | 15 | 0.0744 | 0.2444 | 0.06268 | 220 | 230 | 250 |
| 14 | 15 | 0.0595 | 0.195 | 0.0502 | 220 | 230 | 250 |
| 15 | 17 | 0.0132 | 0.0437 | 0.0444 | 440 | 460 | 500 |
| 15 | 19 | 0.012 | 0.0394 | 0.0101 | 220 | 230 | 250 |
| 15 | 33 | 0.038 | 0.1244 | 0.03194 | 220 | 230 | 250 |
| 16 | 17 | 0.0454 | 0.1801 | 0.0466 | 220 | 230 | 250 |
| 17 | 19 | 0.0123 | 0.0505 | 0.01298 | 220 | 230 | 250 |
| 17 | 31 | 0.0474 | 0.1563 | 0.0399 | 220 | 230 | 250 |
| 17 | 113 | 0.00913 | 0.0301 | 0.00768 | 220 | 230 | 250 |
| 18 | 19 | 0.01119 | 0.0493 | 0.01142 | 220 | 230 | 250 |
| 19 | 20 | 0.0252 | 0.117 | 0.0298 | 220 | 230 | 250 |
| 19 | 34 | 0.0752 | 0.247 | 0.0632 | 220 | 230 | 250 |
| 20 | 21 | 0.0183 | 0.0849 | 0.0216 | 220 | 230 | 250 |
| 21 | 22 | 0.0209 | 0.097 | 0.0246 | 220 | 230 | 250 |
| 22 | 23 | 0.0342 | 0.159 | 0.0404 | 220 | 230 | 250 |
| 23 | 24 | 0.0135 | **0.0492** | 0.0498 | 220 | 230 | 250 |
| 23 | 25 | 0.0156 | 0.08 | 0.0864 | 440 | 460 | 500 |
| 23 | 32 | 0.0317 | 0.1153 | 0.1173 | 220 | 230 | 250 |
| 24 | 70 | 0.00221 | 0.4115 | 0.10198 | 220 | 230 | 250 |

*Table A3: Branch data for the* ***IEEE*** *118-bus network*

255

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| From | To | R | X | B | RateA | RateB | RateC |
| 24 | 72 | 0.0488 | 0.196 | 0.0488 | 220 | 230 | 250 |
| 25 | 27 | 0.0318 | 0.163 | 0.1764 | 440 | 460 | 500 |
| 26 | 25 | 0 | 0.0382 | 0 | 220 | 230 | 250 |
| 26 | 30 | 0.00799 | 0.086 | 0.908 | 660 | 690 | 750 |
| 27 | 28 | 0.01913 | 0.0855 | 0.0216 | 220 | 230 | 250 |
| 27 | 32 | 0.0229 | 0.0755 | 0.01926 | 220 | 230 | 250 |
| 27 | 115 | 0.0164 | 0.0741 | 0.01972 | 220 | 230 | 250 |
| 28 | 31 | 0.0237 | 0.0943 | 0.0238 | 220 | 230 | 250 |
| 29 | 31 | 0.0108 | 0.0331 | 0.0083 | 220 | 230 | 250 |
| 30 | 17 | 0 | 0.0388 | 0 | 660 | 690 | 750 |
| 30 | 38 | 0.00464 | 0.054 | 0.422 | 220 | 230 | 250 |
| 31 | 32 | 0.0298 | 0.0985 | 0.0251 | 220 | 230 | 250 |
| 32 | 113 | 0.0615 | 0.203 | 0.0518 | 220 | 230 | 250 |
| 32 | 114 | 0.0135 | 0.0612 | 0.01628 | 220 | 230 | 250 |
| 33 | 37 | 0.0415 | 0.142 | 0.0366 | 220 | 230 | 250 |
| 34 | 36 | 0.00871 | 0.0268 | 0.00568 | 220 | 230 | 250 |
| 34 | 37 | 0.00256 | 0.0094 | 0.00984 | 440 | 460 | 500 |
| 34 | 43 | 0.0413 | 0.1681 | 0.04226 | 220 | 230 | 250 |
| 35 | 36 | 0.00224 | 0.0102 | 0.00268 | 220 | 230 | 250 |
| 35 | 37 | 0.011 | 0.0497 | 0.01318 | 220 | 230 | 250 |
| 37 | 39 | 0.0321 | 0.106 | 0.027 | 220 | 230 | 250 |
| 37 | 40 | 0.0593 | 0.168 | 0.042 | 220 | 230 | 250 |
| 38 | 37 | 0 | 0.0375 | 0 | 660 | 690 | 750 |
| 38 | 65 | 0.00901 | 0.0986 | 1.046 | ’440 | 460 | 500 |
| 39 | 40 | 0.0184 | 0.0605 | 0.01552 | 220 | 230 | 250 |
| 40 | 41 | 0.0145 | 0.0487 | 0.01222 | 220 | 230 | 250 |
| 40 | 42 | 0.0555 | 0.183 | 0.0466 | 220 | 230 | 250 |
| 41 | 42 | 0.041 | 0.135 | 0.0344 | 220 | 230 | 250 |
| 42 | 49 | 0.0715 | 0.323 | 0.086 | 220 | 230 | 250 |
| 42 | 49 | 0.0715 | 0.323 | 0.086 | 220 | 230 | 250 |
| 43 | 44 | 0.0608 | 0.2454 | 0.06068 | 220 | 230 | 250 |
| 44 | 45 | 0.0224 | 0.0901 | 0.0224 | 220 | 230 | 250 |
| 45 | 46 | 0.04 | 0.1356 | 0.0332 | 220 | 230 | 250 |
| 45 | 49 | 0.0684 | 0.186 | 0.0444 | 220 | 230 | 250 |
| 46 | 47 | 0.038 | 0.127 | 0.0316 | 220 | 230 | 250 |
| 46 | 48 | 0.0601 | 0.189 | 0.0472 | 220 | 230 | 250 |
| 47 | 49 | 0.0191 | 0.0625 | 0.01604 | 220 | 230 | 250 |
| 47 | 69 | 0.0844 | 0.2778 | 0.07092 | 220 | 230 | 250 |
| 48 | 49 | 0.0179 | 0.0505 | 0.01258 | 220 | 230 | 250 |

*Table A3 (continued)*

256

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| From | To | R | X | B | RateA | RateB | RateC |
| 49 | 50 | 0.0267 | 0.0752 | 0.01874 | 220 | 230 | 250 |
| 49 | 51 | 0.0486 | 0.137 | 0.0342 | 220 | 230 | 250 |
| 49 | 54 | 0.073 | 0.289 | 0.0738 | 220 | 230 | 250 |
| 49 | 54 | 0.0869 | 0.291 | 0.073 | 220 | 230 | 250 |
| 49 | 66 | 0.018 | 0.0919 | 0.0248 | 440 | 460 | 500 |
| 49 | 66 | 0.018 | 0.0919 | 0.0248 | 440 | 460 | 500 |
| 49 | 69 | 0.0985 | 0.324 | 0.0828 | 220 | 230 | 250 |
| 50 | 57 | 0.0474 | 0.134 | 0.0332 | 220 | 230 | 250 |
| 51 | 52 | 0.0203 | 0.0588 | 0.01396 | 220 | 230 | 250 |
| 51 | 58 | 0.0255 | 0.0719 | 0.01788 | 220 | 230 | 250 |
| 52 | 53 | 0.0405 | 0.1635 | 0.04058 | 220 | 230 | 250 |
| 53 | 54 | 0.0263 | 0.122 | 0.031 | 220 | 230 | 250 |
| 54 | 55 | 0.0169 | 0.0707 | 0.0202 | 220 | 230 | 250 |
| 54 | 56 | 0.00275 | 0.00955 | 0.00732 | 220 | 230 | 250 |
| 54 | 59 | 0.0503 | 0.2293 | 0.0598 | 220 | 230 | 250 |
| 55 | 56 | 0.00488 | 0.0151 | 0.00374 | 220 | 230 | 250 |
| 55 | 59 | 0.04739 | 0.2158 | 0.05646 | 220 | 230 | 250 |
| 56 | 57 | 0.0343 | 0.0966 | 0.0242 | 220 | 230 | 250 |
| 56 | 58 | 0.0343 | 0.0966 | 0.0242 | 220 | 230 | 250 |
| 56 | 59 | 0.0825 | 0.251 | 0.0569 | 220 | 230 | 250 |
| 56 | 59 | 0.0803 | 0.239 | 0.0536 | 220 | 230 | 250 |
| 59 | 60 | 0.0317 | 0.145 | 0.0376 | 220 | 230 | 250 |
| 59 | 61 | 0.0328 | 0.15 | 0.0388 | 220 | 230 | 250 |
| 60 | 61 | 0.00264 | 0.0135 | 0.01456 | 440 | 460 | 500 |
| 60 | 62 | 0.0123 | 0.0561 | 0.01468 | 220 | 230 | 250 |
| 61 | 62 | 0.00824 | 0.0376 | 0.0098 | 220 | 230 | 250 |
| 62 | 66 | 0.0482 | 0.218 | 0.0578 | 220 | 230 | 250 |
| 62 | 67 | 0.0258 | 0.117 | 0.031 | 220 | 230 | 250 |
| 63 | 59 | 0 | 0.0386 | 0 | 440 | 460 | 500 |
| 63 | 64 | 0.00172 | 0.02 | 0.216 | 440 | 460 | 500 |
| 64 | 61 | 0 | 0.0268 | 0 | 220 | 230 | 250 |
| 64 | 65 | 0.00269 | 0.0302 | 0.38 | 440 | 460 | 500 |
| 65 | 66 | 0 | 0.037 | 0 | 220 | 230 | 250 |
| 65 | 68 | 0.00138 | 0.016 | 0.638 | 220 | 230 | 250 |
| 66 | 67 | 0.0224 | 0.1015 | 0.02682 | 220 | 230 | 250 |
| 68 | 69 | 0 | 0.037 | 0 | 440 | 460 | 500 |
| 68 | 81 | 0.00175 | 0.0202 | 0.808 | 220 | 230 | 250 |
| 68 | 116 | 0.00034 | 0.00405 | 0.164 | 440 | 460 | 500 |
| 69 | 70 | 0.03 | 0.127 | 0.122 | 440 | 460 | 500 |

*Table A3 (continued)*

257

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| From | To | R | X | B | RateA | RateB | RateC |
| 69 | 75 | 0.0405 | 0.122 | 0.124 | 440 | 460 | 500 |
| 69 | 77 | 0.0309 | 0.101 | 0.1038 | 220 | 230 | 250 |
| 70 | 71 | 0.00882 | 0.0355 | 0.00878 | 220 | 230 | 250 |
| 70 | 74 | 0.0401 | 0.1323 | 0.03368 | 220 | 230 | 250 |
| 70 | 75 | 0.0428 | 0.141 | 0.036 | 220 | 230 | 250 |
| 71 | 72 | 0.0446 | 0.18 | 0.04444 | 220 | 230 | 250 |
| 71 | 73 | 0.00866 | 0.0454 | 0.01178 | 220 | 230 | 250 |
| 74 | 75 | 0.0123 | 0.0406 | 0.01034 | 220 | 230 | 250 |
| 75 | 77 | 0.0601 | 0.1999 | 0.04978 | 220 | 230 | 250 |
| 75 | 118 | 0.0145 | 0.0481 | 0.01198 | 220 | 230 | 250 |
| 76 | 77 | 0.0444 | 0.148 | 0.0368 | 220 | 230 | 250 |
| 76 | 118 | 0.0164 | 0.0544 | 0.01356 | 220 | 230 | 250 |
| 77 | 78 | 0.00376 | 0.0124 | 0.01264 | 220 | 230 | 250 |
| 77 | 80 | 0.017 | 0.0485 | 0.0472 | 440 | 460 | 500 |
| 77 | 80 | 0.0294 | 0.105 | 0.0228 | 220 | 230 | 250 |
| 77 | 82 | 0.0298 | 0.0853 | 0.08174 | 220 | 230 | 250 |
| 78 | 79 | 0.00546 | 0.0244 | 0.00648 | 220 | 230 | 250 |
| 79 | 80 | 0.0156 | 0.0704 | 0.0187 | 220 | 230 | 250 |
| 80 | 96 | 0.0356 | 0.182 | 0.0494 | 220 | 230 | 250 |
| 80 | 97 | 0.0183 | 0.0934 | 0.0254 | 220 | 230 | 250 |
| 80 | 98 | 0.0238 | 0.108 | 0.0286 | 220 | 230 | 250 |
| 80 | 99 | 0.0454 | 0.206 | 0.0546 | 220 | 230 | 250 |
| 81 | 80 | 0 | 0.037 | 0 | 220 | 230 | 250 |
| 82 | 83 | 0.0112 | 0.03665 | 0.03796 | 220 | 230 | 250 |
| 82 | 96 | 0.0162 | 0.053 | 0.0544 | 220 | 230 | 250 |
| 83 | 84 | 0.0625 | 0.132 | 0.0258 | 220 | 230 | 250 |
| 83 | 85 | 0.043 | 0.148 | 0.0348 | 220 | 230 | 250 |
| 84 | 85 | 0.0302 | 0.0641 | 0.01234 | 220 | 230 | 250 |
| 85 | 86 | 0.035 | 0.123 | 0.0276 | 220 | 230 | 250 |
| 85 | 88 | 0.02 | 0.102 | 0.0276 | 220 | 230 | 250 |
| 85 | 89 | 0.0239 | 0.173 | 0.047 | 220 | 230 | 250 |
| 86 | 87 | 0.02828 | 0.2074 | 0.0445 | 220 | 230 | 250 |
| 88 | 89 | 0.0139 | 0.0712 | 0.01934 | 440 | 460 | 500 |
| 89 | 90 | 0.0518 | 0.032 | 0.032 | 660 | 230 | 250 |
| 89 | 91 | 0.0099 | 0.032 | 0.065 | 220 | 220 | 220 |
| 89 | 92 | 0.0099 | 0.0505 | 0.065 | 220 | 690 | 750 |
| 90 | 91 | 0.0254 | 0.0505 | 0.065 | 660 | 230 | 250 |
| 91 | 92 | 0.0387 | 0.1272 | 0.032 | 220 | 230 | 250 |
| 92 | 93 | 0.0258 | 0.032 | 0.0218 | 220 | 230 | 250 |

*Table A3 (continued)*

258

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| From | To | R | X | B | RateA | RateB | RateC |
| 92 | 94 | 0.0481 | 0.158 | 0.0406 | 220 | 230 | 250 |
| 92 | 100 | 0.0648 | 0.295 | 0.0472 | 220 | 230 | 250 |
| 92 | 102 | 0.0123 | 0.0559 | 0.01464 | 220 | 230 | 250 |
| 93 | 94 | 0.0223 | 0.0732 | 0.01876 | 220 | 230 | 250 |
| 94 | 95 | 0.0132 | 0.0434 | 0.0111 | 220 | 230 | 250 |
| 94 | 96 | 0.0269 | 0.0869 | 0.023 | 220 | 230 | 250 |
| 94 | 100 | 0.0178 | 0.058 | 0.0604 | 220 | 230 | 250 |
| 95 | 96 | 0.0171 | 0.0547 | 0.01474 | 220 | 230 | 250 |
| 96 | 97 | 0.0173 | 0.0885 | 0.024 | 220 | 230 | 250 |
| 98 | 100 | 0.0397 | 0.179 | 0.0476 | 220 | 230 | 250 |
| 99 | 100 | 0.018 | 0.0813 | 0.0216 | 220 | 230 | 250 |
| 100 | 101 | 0.0277 | 0.1262 | 0.0328 | 220 | 230 | 250 |
| 100 | 103 | 0.016 | 0.0525 | 0.0536 | 440 | 460 | 500 |
| 100 | 104 | 0.0451 | 0.204 | 0.0541 | 220 | 230 | 250 |
| 100 | 106 | 0.0605 | 0.229 | 0.062 | 220. | 230 | 250 |
| 101 | 102 | 0.0246 | 0.112 | 0.0294 | 220 | 230 | 250 |
| 103 | 104 | 0.0466 | 0.1584 | 0.0407 | 220 | 230 | 250 |
| 103 | 105 | 0.0535 | 0.1625 | 0.0408 | 220 | 230 | 250 |
| 103 | 110 | 0.03906 | 0.1813 | 0.0461 | 220 | 230 | 250 |
| 104 | 105 | 0.00994 | 0.0378 | 0.00986 | 220 | 230 | 250 |
| 105 | 106 | 0.014 | 0.0547 | 0.01434 | 220 | 230 | 250 |
| 105 | 107 | 0.053 | 0.183 | 0.0472 | 220 | 230 | 250 |
| 105 | 108 | 0.0261 | 0.0703 | 0.01844 | 220 | 230 | 250 |
| 106 | 107 | 0.053 | 0.183 | 0.0472 | 220 | 230 | 250 |
| 108 | 109 | 0.0105 | 0.0288 | 0.0076 | 220 | 230 | 250 |
| 109 | 110 | 0.0278 | 0.0762 | 0.0202 | 220 | 230 | 250 |
| 110 | 111 | 0.022 | 0.0755 | 0.02 | 220 | 230 | 250 |
| 110 | 112 | 0.0247 | 0.064 | 0.062 | 220 | 230 | 250 |
| 114 | 115 | 0.0023 | 0.0104 | 0.00276 | 220 | 230 | 250 |

*Table A3 (continued)*

259

A4. Generator Marginal Cost Data

Generator marginal costs for the IEEE 118-bus test network are shown in Table A4. The linearized DC power flow used in Chapter 6 of this thesis assumes a constant marginal cost of generation. For simplicity, I assumed that there was no intercept term to the cost curve.

|  |  |
| --- | --- |
| Generator bus | Marginal Cost  ($/MWh) |
| 10 | 0.217 |
| 12 | 1.052 |
| 25 | 0.434 |
| 26 | 0.308 |
| 31 | 5.882 |
| 46 | 3.448 |
| 49 | 0.467 |
| 54 | 1.724 |
| 59 | 0.606 |
| 61 | 0.588 |
| 65 | 0.2493 |
| 66 | 0.2487 |
| 69 | 0.1897 |
| 80 | 0.205 |
| 87 | 7.142 |
| 92 | 10 |
| 100 | 0.381 |
| 103 | 2 |
| 111 | 2.173 |

*Table A4: Generator marginal costs in the IEEE 118-bus network*

260