**Harmonic ranges of current magnitudes with the ranges of the positive and negative sequence impedances for PE devices**

**SVC**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| h | I\_min(%) | I\_max(%) | I\_avg(%) | h | I\_min(%) | I\_max(%) | I\_avg(%) |
| 1 |  |  |  | 21 | 0.0014 | 0.0535 | 0.0275 |
| 2 | 0.0000 | 0.0003 | 0.0002 | 22 | 0.0000 | 0.0000 | 0.0000 |
| 3 | 0.0014 | 0.0463 | 0.0239 | 23 | 0.0546 | 0.3505 | 0.2025 |
| 4 | 0.0000 | 0.0001 | 0.0000 | 24 | 0.0000 | 0.0000 | 0.0000 |
| 5 | 0.6200 | 5.5124 | 3.0662 | 25 | 0.0213 | 0.3651 | 0.1932 |
| 6 | 0.0000 | 0.0000 | 0.0000 | 26 | 0.0000 | 0.0000 | 0.0000 |
| 7 | 0.4444 | 1.7324 | 1.0884 | 27 | 0.0020 | 0.0755 | 0.0388 |
| 8 | 0.0000 | 0.0000 | 0.0000 | 28 | 0.0000 | 0.0000 | 0.0000 |
| 9 | 0.0015 | 0.0304 | 0.0159 | 29 | 0.0044 | 0.2518 | 0.1281 |
| 10 | 0.0000 | 0.0000 | 0.0000 | 30 | 0.0000 | 0.0000 | 0.0000 |
| 11 | 0.0921 | 1.6773 | 0.8847 | 31 | 0.0181 | 0.2788 | 0.1484 |
| 12 | 0.0000 | 0.0000 | 0.0000 | 32 | 0.0000 | 0.0000 | 0.0000 |
| 13 | 0.1067 | 0.6962 | 0.4014 | 33 | 0.0055 | 0.1018 | 0.0536 |
| 14 | 0.0000 | 0.0000 | 0.0000 | 34 | 0.0000 | 0.0000 | 0.0000 |
| 15 | 0.0015 | 0.0368 | 0.0192 | 35 | 0.0187 | 0.1827 | 0.1007 |
| 16 | 0.0000 | 0.0000 | 0.0000 | 36 | 0.0000 | 0.0000 | 0.0000 |
| 17 | 0.0439 | 0.6635 | 0.3537 | 37 | 0.0113 | 0.2529 | 0.1321 |
| 18 | 0.0000 | 0.0000 | 0.0000 | 38 | 0.0000 | 0.0000 | 0.0000 |
| 19 | 0.0257 | 0.5366 | 0.2811 | 39 | 0.0061 | 0.1366 | 0.0713 |
| 20 | 0.0000 | 0.0000 | 0.0000 | 40 | 0.0000 | 0.0000 | 0.0000 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| h | |Z1| range (ohm) | | |Z2| range (ohm) | |
| min | max | min | max |
| 5 | 2008.90 | 2083.57 | 1998.05 | 2100.28 |
| 7 | 3357.17 | 3645.48 | 3360.70 | 3609.70 |
| 11 | 5969.22 | 6571.55 | 5919.97 | 6543.14 |
| 13 | 7276.81 | 8125.20 | 7333.15 | 8087.13 |
| 15 | 8869.42 | 9727.35 | 8769.06 | 9715.87 |

**WT Type 3**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| h | I\_min(%) | I\_max(%) | I\_avg(%) | h | I\_min(%) | I\_max(%) | I\_avg(%) |
| 1 |  |  |  | 21 | 0.0023 | 0.0281 | 0.0152 |
| 2 | 0.0078 | 0.0838 | 0.0458 | 22 | 0.0175 | 0.1423 | 0.0799 |
| 3 | 0.0027 | 0.0935 | 0.0481 | 23 | 0.0001 | 0.0345 | 0.0173 |
| 4 | 0.0015 | 0.1344 | 0.0679 | 24 | 0.0088 | 0.0905 | 0.0496 |
| 5 | 0.0490 | 0.7690 | 0.4090 | 25 | 0.0002 | 0.0177 | 0.0089 |
| 6 | 0.0075 | 0.1721 | 0.0898 | 26 | 0.0002 | 0.0087 | 0.0045 |
| 7 | 0.0136 | 0.3844 | 0.1990 | 27 | 0.0006 | 0.0119 | 0.0062 |
| 8 | 0.0060 | 0.1518 | 0.0789 | 28 | 0.0005 | 0.0140 | 0.0073 |
| 9 | 0.0052 | 0.0904 | 0.0478 | 29 | 0.0006 | 0.0176 | 0.0091 |
| 10 | 0.0029 | 0.0885 | 0.0457 | 30 | 0.0004 | 0.0090 | 0.0047 |
| 11 | 0.0010 | 0.1333 | 0.0671 | 31 | 0.0010 | 0.0230 | 0.0120 |
| 12 | 0.0030 | 0.1400 | 0.0715 | 32 | 0.0000 | 0.0063 | 0.0031 |
| 13 | 0.0047 | 0.1065 | 0.0556 | 33 | 0.0011 | 0.0177 | 0.0094 |
| 14 | 0.0028 | 0.0383 | 0.0206 | 34 | 0.0003 | 0.0088 | 0.0046 |
| 15 | 0.0052 | 0.1361 | 0.0706 | 35 | 0.0002 | 0.0217 | 0.0109 |
| 16 | 0.0200 | 0.2426 | 0.1313 | 36 | 0.0002 | 0.0045 | 0.0024 |
| 17 | 0.0037 | 0.0852 | 0.0444 | 37 | 0.0227 | 0.3236 | 0.1731 |
| 18 | 0.0284 | 0.2950 | 0.1617 | 38 | 0.0004 | 0.0055 | 0.0029 |
| 19 | 0.0017 | 0.0393 | 0.0205 | 39 | 0.0042 | 0.0545 | 0.0293 |
| 20 | 0.0053 | 0.0931 | 0.0492 | 40 | 0.0000 | 0.0051 | 0.0026 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| h | |Z1| range (ohm) | | |Z2| range (ohm) | |
| min | max | min | max |
| 5 | 336.25 | 977.82 | 300.32 | 636.61 |
| 7 | 162.13 | 1228.32 | 226.74 | 329.00 |
| 11 | 415.69 | 588.64 | 463.40 | 593.53 |
| 13 | 473.61 | 614.24 | 292.73 | 671.61 |
| 15 | 205.73 | 420.02 | 259.14 | 400.42 |

**WT Type 4**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| h | I\_min(%) | I\_max(%) | I\_avg(%) | h | I\_min(%) | I\_max(%) | I\_avg(%) |
| 1 |  |  |  | 21 | 0.0035 | 0.1367 | 0.0701 |
| 2 | 0.0157 | 0.2224 | 0.1191 | 22 | 0.0018 | 0.0413 | 0.0215 |
| 3 | 0.0265 | 0.6226 | 0.3246 | 23 | 0.0045 | 0.0402 | 0.0224 |
| 4 | 0.0369 | 0.2579 | 0.1474 | 24 | 0.0018 | 0.0144 | 0.0081 |
| 5 | 0.3211 | 1.7053 | 1.0132 | 25 | 0.0006 | 0.0303 | 0.0155 |
| 6 | 0.0055 | 0.0946 | 0.0501 | 26 | 0.0047 | 0.0503 | 0.0275 |
| 7 | 0.3072 | 1.0548 | 0.6810 | 27 | 0.0018 | 0.0183 | 0.0101 |
| 8 | 0.0061 | 0.0907 | 0.0484 | 28 | 0.0358 | 0.2048 | 0.1203 |
| 9 | 0.0233 | 0.1380 | 0.0806 | 29 | 0.0022 | 0.0122 | 0.0072 |
| 10 | 0.0216 | 0.0840 | 0.0528 | 30 | 0.0015 | 0.0176 | 0.0095 |
| 11 | 0.0384 | 0.2801 | 0.1593 | 31 | 0.0009 | 0.0139 | 0.0074 |
| 12 | 0.0006 | 0.0377 | 0.0191 | 32 | 0.0411 | 0.2407 | 0.1409 |
| 13 | 0.0215 | 0.3413 | 0.1814 | 33 | 0.0006 | 0.0065 | 0.0036 |
| 14 | 0.0134 | 0.0778 | 0.0456 | 34 | 0.0021 | 0.0691 | 0.0356 |
| 15 | 0.0059 | 0.2233 | 0.1146 | 35 | 0.0006 | 0.0055 | 0.0030 |
| 16 | 0.0094 | 0.1094 | 0.0594 | 36 | 0.0026 | 0.0116 | 0.0071 |
| 17 | 0.0033 | 0.1448 | 0.0741 | 37 | 0.0004 | 0.0081 | 0.0043 |
| 18 | 0.0023 | 0.0403 | 0.0213 | 38 | 0.0074 | 0.0331 | 0.0203 |
| 19 | 0.0131 | 0.1402 | 0.0766 | 39 | 0.0010 | 0.0334 | 0.0172 |
| 20 | 0.0035 | 0.0432 | 0.0234 | 40 | 0.0017 | 0.0274 | 0.0146 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| h | |Z1| range (ohm) | | |Z2| range (ohm) | |
| min | max | min | max |
| 5 | 191.64 | 872.27 | 113.56 | 1595.31 |
| 7 | 156.99 | 1048.65 | 348.35 | 1780.54 |
| 11 | 336.60 | 1191.12 | 50.39 | 1555.54 |
| 13 | 55.72 | 650.50 | 185.13 | 620.80 |
| 15 | 144.56 | 669.37 | 323.63 | 8204.73 |

**PV**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| h | I\_min(%) | I\_max(%) | I\_avg(%) | h | I\_min(%) | I\_max(%) | I\_avg(%) |
| 1 |  |  |  | 21 | 0.0001 | 0.0503 | 0.0252 |
| 2 | 0.0172 | 0.7681 | 0.3926 | 22 | 0.0580 | 0.2820 | 0.1700 |
| 3 | 0.0046 | 0.4194 | 0.2120 | 23 | 0.0012 | 0.0384 | 0.0198 |
| 4 | 0.0914 | 0.9772 | 0.5343 | 24 | 0.0053 | 0.0611 | 0.0332 |
| 5 | 0.0009 | 0.2486 | 0.1248 | 25 | 0.0009 | 0.0318 | 0.0164 |
| 6 | 0.0032 | 0.1848 | 0.0940 | 26 | 0.0005 | 0.0465 | 0.0235 |
| 7 | 0.0057 | 0.1839 | 0.0948 | 27 | 0.0012 | 0.0447 | 0.0229 |
| 8 | 0.0015 | 0.0745 | 0.0380 | 28 | 0.0009 | 0.0356 | 0.0183 |
| 9 | 0.0021 | 0.0741 | 0.0381 | 29 | 0.0025 | 0.0362 | 0.0193 |
| 10 | 0.0010 | 0.1592 | 0.0801 | 30 | 0.0015 | 0.0303 | 0.0159 |
| 11 | 0.0030 | 0.1005 | 0.0518 | 31 | 0.0012 | 0.0706 | 0.0359 |
| 12 | 0.0021 | 0.0647 | 0.0334 | 32 | 0.0024 | 0.0337 | 0.0181 |
| 13 | 0.0014 | 0.0623 | 0.0319 | 33 | 0.0025 | 0.0615 | 0.0320 |
| 14 | 0.0018 | 0.0279 | 0.0149 | 34 | 0.0018 | 0.0385 | 0.0201 |
| 15 | 0.0081 | 0.1279 | 0.0680 | 35 | 0.0053 | 0.0714 | 0.0383 |
| 16 | 0.0013 | 0.0498 | 0.0255 | 36 | 0.0020 | 0.0497 | 0.0259 |
| 17 | 0.0577 | 0.2461 | 0.1519 | 37 | 0.0023 | 0.0495 | 0.0259 |
| 18 | 0.0034 | 0.0605 | 0.0320 | 38 | 0.0006 | 0.0686 | 0.0346 |
| 19 | 0.0016 | 0.0549 | 0.0282 | 39 | 0.0021 | 0.0460 | 0.0241 |
| 20 | 0.0246 | 0.3902 | 0.2074 | 40 | 0.0016 | 0.0690 | 0.0353 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| h | |Z1| range (ohm) | | |Z2| range (ohm) | |
| min | max | min | max |
| 5 | 2157.43 | 3169.88 | 2741.08 | 3174.85 |
| 7 | 3185.78 | 4284.59 | 3918.17 | 4563.85 |
| 11 | 5531.39 | 5896.29 | 5835.63 | 6620.19 |
| 13 | 6487.92 | 7382.68 | 7047.45 | 8191.60 |
| 15 | 7823.78 | 8549.69 | 8279.82 | 8993.49 |

**HVDC**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| h | I\_min(%) | I\_max(%) | I\_avg(%) | h | I\_min(%) | I\_max(%) | I\_avg(%) |
| 1 |  |  |  | 21 | 0.0001 | 0.1018 | 0.0510 |
| 2 | 0.0063 | 0.0732 | 0.0398 | 22 | 0.0000 | 0.0467 | 0.0233 |
| 3 | 0.0023 | 0.6394 | 0.3209 | 23 | 0.0001 | 0.0688 | 0.0345 |
| 4 | 0.0065 | 0.0815 | 0.0440 | 24 | 0.0000 | 0.0291 | 0.0146 |
| 5 | 0.0764 | 0.4910 | 0.2837 | 25 | 0.0001 | 0.0560 | 0.0280 |
| 6 | 0.0087 | 0.0463 | 0.0275 | 26 | 0.0002 | 0.0033 | 0.0018 |
| 7 | 0.0176 | 0.2416 | 0.1296 | 27 | 0.0001 | 0.0176 | 0.0089 |
| 8 | 0.0009 | 0.0308 | 0.0159 | 28 | 0.0001 | 0.0051 | 0.0026 |
| 9 | 0.0021 | 0.2224 | 0.1123 | 29 | 0.0002 | 0.0236 | 0.0119 |
| 10 | 0.0018 | 0.0213 | 0.0115 | 30 | 0.0003 | 0.0049 | 0.0026 |
| 11 | 0.0016 | 0.0768 | 0.0392 | 31 | 0.0002 | 0.0324 | 0.0163 |
| 12 | 0.0020 | 0.0502 | 0.0261 | 32 | 0.0001 | 0.0086 | 0.0043 |
| 13 | 0.0027 | 0.0932 | 0.0480 | 33 | 0.0002 | 0.0290 | 0.0146 |
| 14 | 0.0004 | 0.0217 | 0.0110 | 34 | 0.0001 | 0.0028 | 0.0014 |
| 15 | 0.0003 | 0.0433 | 0.0218 | 35 | 0.0002 | 0.0227 | 0.0114 |
| 16 | 0.0006 | 0.0834 | 0.0420 | 36 | 0.0002 | 0.0040 | 0.0021 |
| 17 | 0.0025 | 0.1409 | 0.0717 | 37 | 0.0001 | 0.1115 | 0.0558 |
| 18 | 0.0005 | 0.1008 | 0.0506 | 38 | 0.0000 | 0.0092 | 0.0046 |
| 19 | 0.0019 | 0.0766 | 0.0393 | 39 | 0.0001 | 0.0194 | 0.0097 |
| 20 | 0.0003 | 0.0300 | 0.0152 | 40 | 0.0000 | 0.0036 | 0.0018 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| h | |Z1| range (ohm) | | |Z2| range (ohm) | |
| min | max | min | max |
| 5 | 123.76 | 153.95 | 152.11 | 290.96 |
| 7 | 157.78 | 309.17 | 321.30 | 372.02 |
| 11 | 375.65 | 450.41 | 507.76 | 819.68 |
| 13 | 473.19 | 884.08 | 593.89 | 671.58 |
| 15 | 637.73 | 692.73 | 702.49 | 787.59 |

**STATCOM**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| h | I\_min(%) | I\_max(%) | I\_avg(%) | h | I\_min(%) | I\_max(%) | I\_avg(%) |
| 1 |  |  |  | 21 | 0.0069 | 0.1122 | 0.0595 |
| 2 | 0.0023 | 0.0366 | 0.0195 | 22 | 0.0019 | 0.0442 | 0.0231 |
| 3 | 0.0067 | 0.0883 | 0.0475 | 23 | 0.0141 | 0.1289 | 0.0715 |
| 4 | 0.0029 | 0.0678 | 0.0354 | 24 | 0.0034 | 0.0499 | 0.0266 |
| 5 | 0.0056 | 0.0986 | 0.0521 | 25 | 0.0290 | 0.4609 | 0.2450 |
| 6 | 0.0029 | 0.0468 | 0.0248 | 26 | 0.0013 | 0.0361 | 0.0187 |
| 7 | 0.0099 | 0.0882 | 0.0490 | 27 | 0.0047 | 0.1472 | 0.0760 |
| 8 | 0.0030 | 0.0610 | 0.0320 | 28 | 0.0011 | 0.0281 | 0.0146 |
| 9 | 0.0050 | 0.0717 | 0.0383 | 29 | 0.0204 | 0.2178 | 0.1191 |
| 10 | 0.0070 | 0.0951 | 0.0511 | 30 | 0.0013 | 0.0307 | 0.0160 |
| 11 | 0.0065 | 0.1513 | 0.0789 | 31 | 0.0373 | 0.4623 | 0.2498 |
| 12 | 0.0063 | 0.0590 | 0.0327 | 32 | 0.0010 | 0.0320 | 0.0165 |
| 13 | 0.0064 | 0.0798 | 0.0431 | 33 | 0.0061 | 0.2416 | 0.1239 |
| 14 | 0.0032 | 0.0621 | 0.0327 | 34 | 0.0010 | 0.0321 | 0.0165 |
| 15 | 0.0071 | 0.0643 | 0.0357 | 35 | 0.0146 | 0.2677 | 0.1411 |
| 16 | 0.0024 | 0.0438 | 0.0231 | 36 | 0.0036 | 0.0245 | 0.0140 |
| 17 | 0.0023 | 0.1076 | 0.0549 | 37 | 0.0527 | 0.2350 | 0.1439 |
| 18 | 0.0022 | 0.0316 | 0.0169 | 38 | 0.0012 | 0.0264 | 0.0138 |
| 19 | 0.0066 | 0.1578 | 0.0822 | 39 | 0.0145 | 0.1845 | 0.0995 |
| 20 | 0.0025 | 0.0224 | 0.0125 | 40 | 0.0006 | 0.0215 | 0.0110 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| h | |Z1| range (ohm) | | |Z2| range (ohm) | |
| min | max | min | max |
| 5 | 1752.99 | 3187.18 | 6056.75 | 63476.65 |
| 7 | 4460.32 | 11318.00 | 4565.07 | 7169.66 |
| 11 | 3891.23 | 18967.56 | 4348.38 | 31952.38 |
| 13 | 6509.59 | 23788.60 | 5591.36 | 9338.12 |
| 15 | 3005.89 | 4254.81 | 6273.45 | 11912.32 |