Horsham Solar Farm and BESS

Harmonic Emissions Assessment and Filter Design

4th June 2024

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| **Document Information** | |
| **File Ref:** | 20240406\_HSFBESS\_PQReport |
| **Version:** | v1 |
| **Distribution:** | For distribution to AEMO as part of connection application |

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# Revision History

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Revision** | **Description** | **Author** | **Review** | **Approval** | **Date** |
| v1 | First Issue as per the data pack | Michael M | Dao V | Mervin K | 04/06/2024 |
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# Defined Terms

|  |  |
| --- | --- |
| **Term** | **Definition** |
| AAS | Automatic Access Standard |
| AC | Alternating Current |
| AF | Amplification Factor |
| BESS | Battery Energy Storage System |
| CPTSR | Connection Point Technical Specification Report |
| DC | Direct Current |
| EMT | Electromagnetic Transient |
| FFT | Fast Fourier Transform |
| HD | Harmonic Distortion |
| IEC | International Electrotechnical Commission |
| HV | High Voltage |
| kV | Kilovolt, equivalent to 103 volts |
| LV | Low voltage |
| MAS | Minimum Access Standard |
| MVA | Megavolt-ampere, equivalent to 106 volt ampere |
| MVAr | Megavolt-ampere reactive, equivalent to 106 volt-amperes reactive |
| MW | Megawatt, equivalent to 106 watts |
| NER | National Electricity Rules |
| OEM | Original Equipment Manufacturer |
| PCS | Power Conversion System |
| POC | Point of Connection |
| PQ | Power Quality |
| pu | Per Unit |
| SLD | Single Line Diagram |
| THD | Total Harmonic Distortion |
| TNSP | Transmission Network Service Provider |
| Tx | Transformer |

# Generators Nomenclature

|  |  |
| --- | --- |
| Generator Name | Nomenclature in the report |
| HSFBESS | Horsham Solar Farm and BESS – 119MWac |

# Executive Summary

OX2 Australia is proposing to connect Horsham Solar Farm (HSFBESS) into the AEMO network in Horsham Victoria. Horsham Solar Farm (HSFBESS) consists of 36 x 4.2MVA SMA SC4200 UP PV inverters and 40 x 3.6MVA SMA SCS3600 UP-XT BESS inverters. HSFBESS active power export capacity will be limited to 119MW at 220kV Point of Connection (POC).

This report forms a part of the Horsham Solar Farm connection application to AEMO. The studies were conducted as per the AEMO Harmonic Studies Preliminary Guidelines in DigSILENT PowerFactory 2023. This includes total harmonic distortion (THD), individual harmonic distortion (HD), and amplification factor (AF).

The aim of the report is to:

* Provide network modelling and study execution details.
* Demonstrate the methodology used in calculations.
* To show the proposed plant impact on voltage harmonic distortion.
* Propose harmonic filters that would mitigate the harmonic emissions and comply with the planning and AAS allocation limits.

A harmonic assessment was conducted by OX2 Australia based on NER requirement clause S5.2.5.2 and the harmonic limits specified by AEMO. The findings of the assessment are summarised below:

* With the connection of HSFBESS, the voltage harmonic distortion at the POC exceeds the planning and AAS allocation limits for several orders. Orders 7, 10, 11, 13, 14, 15, 16, 17, 28, 29, 35, 37, 38, 40, 41, 43, 44, 46, 47, 49, and 50 were found to exceed the limits. Moreover, significant amplification at the POC was observed with the connection of the generating system, with the 17th order having the maximum amplification factor at 1.55.
* To reduce the harmonic emissions at the POC, four different harmonic filters are proposed, and the calculation study was repeated to consider the effects of filters.
* With the harmonic filters in service, the harmonic emissions comply with the planning and allocation limits. Also, the amplification factors at the POC were alleviated and are closer to unity for the complete frequency range.

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# Introduction

## Project Details

OX2 Australia is developing Horsham Solar Farm and BESS (HSFBESS) with maximum active power output of 119 MWac connecting to AEMO network. This report presents the harmonic-voltage calculation study methodology consisting of the following assessments:

1. Total harmonic distortion
2. Voltage harmonic distortion
3. Amplification factor
4. Evaluation of harmonic emissions against planning and allocation limits
5. Harmonic filter design

## Site Information

Table 1 Site Information

|  |  |
| --- | --- |
| Variable | Value |
| Lot/DP | Multiple Lots |
| Address | Horsham-Lubeck Road, Riverside, VIC 3401 |
| LGA | Horsham Rural City Council |

## Connection Details

Table 2 Connection Details

|  |  |
| --- | --- |
| Variable | Value |
| NSP | Ausnet |
| Supply Area | Horsham |
| Point of Connection Voltage | 220 kV |
| Feeder Name | N/A |
| Relevant Zone Substation | Horsham 220/66 kV Terminal Station |

# Model Construction

This chapter’s emphasis is on the input data required and the methodology used to construct the network model integrated with Horsham Solar Farm and BESS. The AS/NZS61000.3.6 has been followed in the calculation of harmonic emissions and the software used for the network modelling and analysis is DIgSILENT PowerFactory 2023. AEMO's recommended harmonic limits are then used to compare the results.

## Input Data

The network models and the harmonic studies are based upon the data outlined in the table below.

Table 3 Input data references

|  |  |  |
| --- | --- | --- |
| Variable | Value | Source |
| Harmonic Studies Preliminary Guideline | Harmonic Studies Preliminary Guideline.docx | AEMO |
| Harmonic Impedance Scans | 20230207\_HOTS\_BESS\_ Impedance Scans.xlsx | AEMO |
| Background Harmonics | MWTS\_20230130\_20230222\_BackgroundHarmonics.xlsx | AEMO |
| Allocation Limits | 20230228\_RE Horsham SF - background Harmonics.msg | AEMO |
| Solar Inverters/BESS Inverters | SMA SC 4200 UP  SMA SCS 3600 UP\_XT | SMA |
| Single Line Diagram | HOR-DE-3001-RQ\_HV SLD.pdf  HOR-DE-3003-RH\_BESS 33kV SLD.pdf | OX2 Australia |
| Cable Schedule | HOSF-SMEC-EL-06-MVS-SCH-10\_MV Cable Schedule-B.pdf | SMEC |
| Cable Impedances | 20220926\_HORSF\_Cable\_Aggr.xlsx  180514\_LAN\_MV\_CABLE\_Losses.xlsx | OX2 Australia |

## HSFBESS Plant Model

Figure 1 shows the SLD constructed in DIgSILENT PowerFactory to represent HSFBESS. This includes all relevant components such as:

* External Grid Equivalent
* Main Transformer
* Transformer Excitation Currents (Inverter and Main Transformers)
* Cables
* Norton Equivalent of Inverters (PV and BESS)
* Harmonic Filter Banks

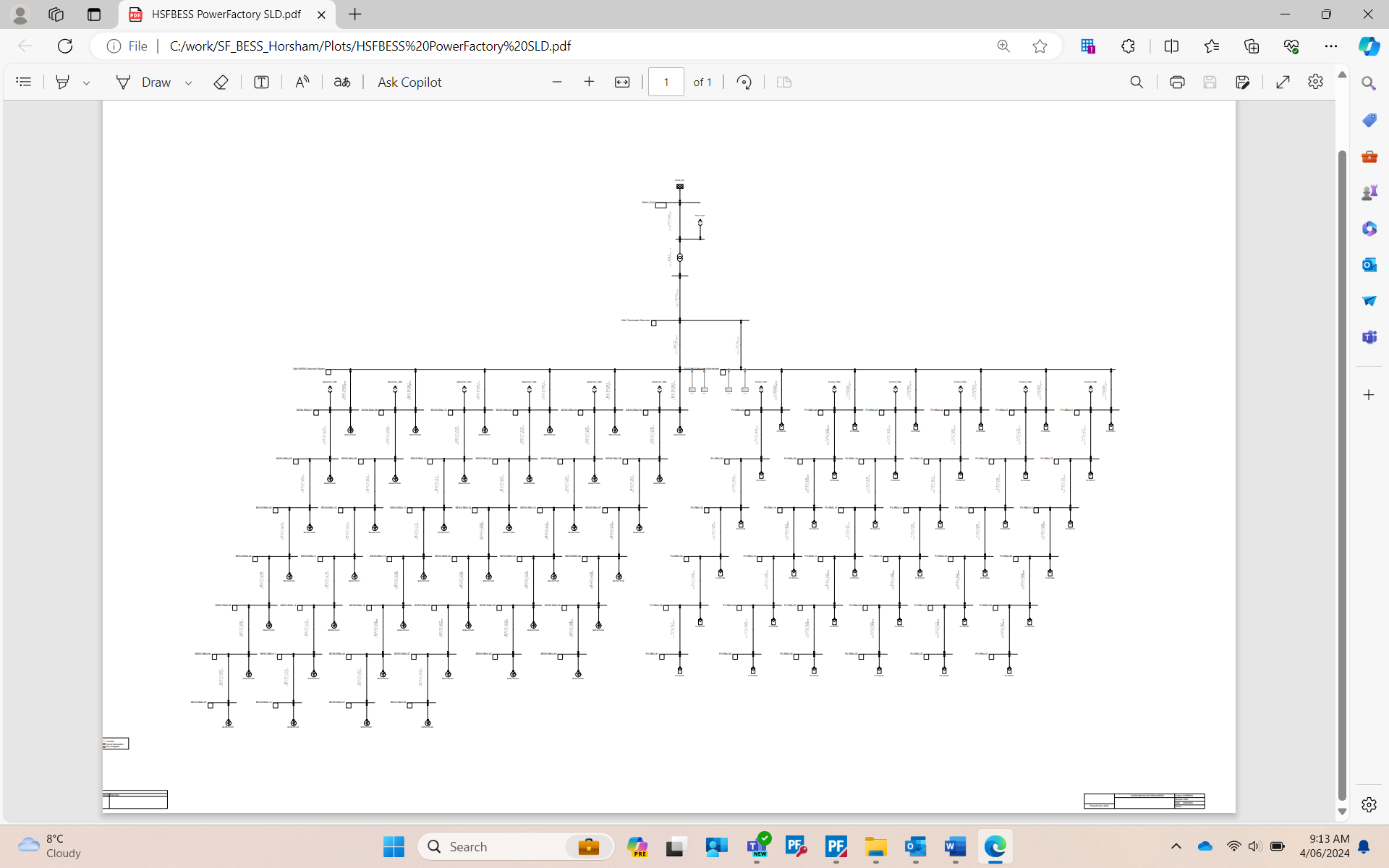


Figure 1 Single Line Diagram in DIgSILENT PowerFactory

HSFBESS consists of 36 x 4.2MVA SMA SC4200 UP PV inverters and 40 x 3.6MVA SMA SCS3600 UP-XT BESS inverters connected to the 220kV connection point via a 170MVA, 220/33 kV Main Transformer.

## External Grid Equivalent

### Harmonic-Impedance Polygons

Network harmonic impedance scan data at the HSFBESS 220kV PoC was provided by AEMO and was used in modeling the external grid component in the SLD constructed in DIgSILENT PowerFactory.

The built-in impedance loci script in PowerFactory is used to perform iterative harmonic load flow calculation based on R-X values, within the area defined by the harmonic-impedance polygon, resulting in the highest voltage harmonic distortion at each harmonic frequency.

### Background Harmonic Distortion

The planning limits used in this study are based on Table 2 of [1] - Indicative planning levels of harmonic voltages (in percent of the fundamental voltage) in MV, HV, and EHV power systems.

The background harmonic distortion spectrum for orders 2nd-14th used are based on AEMO provided data. These are represented by the 95% percentile values. The 15th-50th harmonic orders were assumed as 50% of the corresponding planning limit based on [2].

Table 4 shows both the planning levels and background harmonic distortion used in the modeling and analysis.

Table 4 Planning Levels and Background Harmonic Distortion Information

| Harmonic Order | Planning Limits (%) | Background Harmonic Distortion (%) | Background Harmonic Distortion (pu, as entered in PowerFactory) |
| --- | --- | --- | --- |
| 2 | 1.400 | 0.5005 | 0.0050 |
| 3 | 2.000 | 0.2433 | 0.0024 |
| 4 | 0.800 | 0.1977 | 0.0020 |
| 5 | 2.000 | 0.7095 | 0.0071 |
| 6 | 0.400 | 0.1040 | 0.0010 |
| 7 | 2.000 | 0.3407 | 0.0034 |
| 8 | 0.400 | 0.1224 | 0.0012 |
| 9 | 1.000 | 0.1241 | 0.0012 |
| 10 | 0.350 | 0.0909 | 0.0009 |
| 11 | 1.500 | 0.1777 | 0.0018 |
| 12 | 0.318 | 0.0727 | 0.0007 |
| 13 | 1.500 | 0.1895 | 0.0019 |
| 14 | 0.296 | 0.0720 | 0.0007 |
| 15 | 0.300 | 0.1500 | 0.0015 |
| 16 | 0.279 | 0.1394 | 0.0014 |
| 17 | 1.200 | 0.6000 | 0.0060 |
| 18 | 0.266 | 0.1328 | 0.0013 |
| 19 | 1.074 | 0.5368 | 0.0054 |
| 20 | 0.255 | 0.1275 | 0.0013 |
| 21 | 0.200 | 0.1000 | 0.0010 |
| 22 | 0.246 | 0.1232 | 0.0012 |
| 23 | 0.887 | 0.4435 | 0.0044 |
| 24 | 0.239 | 0.1196 | 0.0012 |
| 25 | 0.816 | 0.4080 | 0.0041 |
| 26 | 0.233 | 0.1165 | 0.0012 |
| 27 | 0.200 | 0.1000 | 0.0010 |
| 28 | 0.228 | 0.1139 | 0.0011 |
| 29 | 0.703 | 0.3517 | 0.0035 |
| 30 | 0.223 | 0.1117 | 0.0011 |
| 31 | 0.658 | 0.3290 | 0.0033 |
| 32 | 0.219 | 0.1097 | 0.0011 |
| 33 | 0.200 | 0.1000 | 0.0010 |
| 34 | 0.216 | 0.1079 | 0.0011 |
| 35 | 0.583 | 0.2914 | 0.0029 |
| 36 | 0.213 | 0.1064 | 0.0011 |
| 37 | 0.551 | 0.2757 | 0.0028 |
| 38 | 0.210 | 0.1050 | 0.0011 |
| 39 | 0.200 | 0.1000 | 0.0010 |
| 40 | 0.208 | 0.1038 | 0.0010 |
| 41 | 0.498 | 0.2488 | 0.0025 |
| 42 | 0.205 | 0.1026 | 0.0010 |
| 43 | 0.474 | 0.2372 | 0.0024 |
| 44 | 0.203 | 0.1016 | 0.0010 |
| 45 | 0.200 | 0.1000 | 0.0010 |
| 46 | 0.201 | 0.1007 | 0.0010 |
| 47 | 0.434 | 0.2170 | 0.0022 |
| 48 | 0.200 | 0.0998 | 0.0010 |
| 49 | 0.416 | 0.2082 | 0.0021 |
| 50 | 0.198 | 0.0990 | 0.0010 |

## Main Transformer

Table 5 shows the parameters used for the Main Transformer model. The frequency-dependency characteristics of the Main Transformer resistance were modeled based on Equation 3.15 of [3] using values of 0.75, 0.12, 0.13, and 1.4 for respectively. Appendix 9.1 shows the equation used in modeling. Table 6 shows the resulting frequency-dependency characteristic of the per-unit positive sequence resistance, r1(h)/r1.

Table 5 Main Transformer parameters

|  |  |
| --- | --- |
| **Name** | 220/33 kV 170 MVA TX |
| **Rated Power (MVA)** | 170 |
| **Nominal Frequency (Hz)** | 50 |
| **HV-Rated Voltage (kV)** | 220 |
| **LV-Rated Voltage (kV)** | 33 |
| **Impedance (%)** | 16.80 |
| **Ratio X/R** | 47.60 |
| **x1 (pu)** | 0.168 |
| **r1 (pu)** | 0.003529 |
| **Vector Group** | YNd11 |
| **x0** **(pu)** | 0.147961 |
| **r0 (pu)** | 0.003529 |

Table 6 Main Transformer frequency-dependency characteristics

|  |  |  |  |
| --- | --- | --- | --- |
| Harmonic Order | Positive Sequence Resistance r1(h)/r1 | Harmonic Order | Positive Sequence Resistance r1(h)/r1 |
| 0 | 0.75 | 26 | 100.12 |
| 1 | 1. | 27 | 107.63 |
| 2 | 1.59 | 28 | 115.41 |
| 3 | 2.48 | 29 | 123.46 |
| 4 | 3.67 | 30 | 131.78 |
| 5 | 5.14 | 31 | 140.37 |
| 6 | 6.9 | 32 | 149.23 |
| 7 | 8.95 | 33 | 158.36 |
| 8 | 11.28 | 34 | 167.75 |
| 9 | 13.88 | 35 | 177.41 |
| 10 | 16.76 | 36 | 187.34 |
| 11 | 19.92 | 37 | 197.54 |
| 12 | 23.36 | 38 | 208.01 |
| 13 | 27.07 | 39 | 218.74 |
| 14 | 31.06 | 40 | 229.74 |
| 15 | 35.32 | 41 | 241.01 |
| 16 | 39.85 | 42 | 252.55 |
| 17 | 44.66 | 43 | 264.35 |
| 18 | 49.73 | 44 | 276.42 |
| 19 | 55.08 | 45 | 288.76 |
| 20 | 60.7 | 46 | 301.36 |
| 21 | 66.6 | 47 | 314.23 |
| 22 | 72.76 | 48 | 327.37 |
| 23 | 79.19 | 49 | 340.77 |
| 24 | 85.9 | 50 | 354.44 |
| 25 | 92.87 | - | - |

## Transformer Excitation Currents

To obtain estimates of the maximum transformer excitation harmonic current magnitudes, a model was built in DigSilent PowerFactory using available transformer saturation data and a harmonic load flow simulation was performed. The analysis considered the highest expected 50 Hz voltages applied across the unloaded transformer terminals, and harmonic currents were extracted on the HV side. For the inverter transformers, the same methodology was applied but the magnitude of the excitation current at fundamental frequency was multiplied by six/seven to represent the contribution from the six/seven transformer per collector feeder.

Table 7 shows the resulting harmonic magnitudes of excitation current which are then used as input in the HSFBESS PowerFactory model.

Table 7 Transformer excitation harmonic currents

| Harmonic Order | Excitation Current (% of fundamental) | | |
| --- | --- | --- | --- |
| Main Transformer | 6 Inverter Transformers | 7 Inverter Transformers |
| 2 | 0.00006683 | 0.00000468 | 0.00000679 |
| 3 | 0.00000317 | 0.00000235 | 0.00000451 |
| 4 | 0.00001692 | 0.00000647 | 0.00000657 |
| 5 | 0.00000633 | 0.00000128 | 0.00000542 |
| 6 | 0.00000189 | 0.00000065 | 0.00000271 |
| 7 | 0.00000729 | 0.00000332 | 0.00000453 |
| 8 | 0.00000049 | 0.00000213 | 0.00000138 |
| 9 | 0.00000932 | 0.00000182 | 0.00000132 |
| 10 | 0.00001205 | 0.00000197 | 0.00000155 |
| 11 | 0.00000953 | 0.00000081 | 0.00000051 |
| 12 | 0.00000235 | 0.00000129 | 0.0000004 |
| 13 | 0.00001054 | 0.00000248 | 0.00000178 |
| 14 | 0.00000053 | 0.00000024 | 0.00000153 |
| 15 | 0.00000347 | 0.00000039 | 0.00000087 |
| 16 | 0.0000066 | 0.00000152 | 0.00000086 |
| 17 | 0.00000245 | 0.0000008 | 0.00000105 |
| 18 | 0.00000885 | 0.0000008 | 0.00000125 |
| 19 | 0.00000475 | 0.00000028 | 0.00000039 |
| 20 | 0.0000011 | 0.00000127 | 0.00000015 |
| 21 | 0.0000101 | 0.00000162 | 0.00000066 |
| 22 | 0.00000171 | 0.00000027 | 0.0000008 |
| 23 | 0.00000175 | 0.00000035 | 0.00000017 |
| 24 | 0.00000181 | 0.00000036 | 0.00000118 |
| 25 | 0.00000731 | 0.00000067 | 0.00000089 |
| 26 | 0.00000621 | 0.00000089 | 0.00000047 |
| 27 | 0.00000178 | 0.00000086 | 0.00000074 |
| 28 | 0.00000512 | 0.00000112 | 0.00000064 |
| 29 | 0.00000623 | 0.00000039 | 0.00000085 |
| 30 | 0.00000341 | 0.0000005 | 0.00000069 |
| 31 | 0.0000004 | 0.00000016 | 0.00000067 |
| 32 | 0.00000033 | 0.00000155 | 0.00000041 |
| 33 | 0.00000039 | 0.00000068 | 0.00000093 |
| 34 | 0.00000257 | 0.00000037 | 0.00000048 |
| 35 | 0.00000136 | 0.00000055 | 0.00000009 |
| 36 | 0.00000473 | 0.00000098 | 0.00000071 |
| 37 | 0.00000376 | 0.00000028 | 0.00000009 |
| 38 | 0.0000005 | 0.00000006 | 0.00000023 |
| 39 | 0.00000102 | 0.00000104 | 0.00000061 |
| 40 | 0.00000443 | 0.00000147 | 0.00000069 |
| 41 | 0.00000051 | 0.00000048 | 0.00000053 |
| 42 | 0.00000075 | 0.00000032 | 0.00000032 |
| 43 | 0.00000114 | 0.00000089 | 0.00000066 |
| 44 | 0.00000173 | 0.00000012 | 0.00000069 |
| 45 | 0.00000013 | 0.00000016 | 0.00000004 |
| 46 | 0.00000065 | 0.00000021 | 0.00000027 |
| 47 | 0.00000044 | 0.00000033 | 0.00000053 |
| 48 | 0.00000184 | 0.00000034 | 0.0000002 |
| 49 | 0.00000396 | 0.00000057 | 0.00000058 |
| 50 | 0.0000059 | 0.00000039 | 0.00000018 |

## Cables

Each cable type is modeled in PowerFactory with the parameters in Table 8. To consider the skin effect of cables, a Frequency Polynomial Characteristic described in equation (1) based in [4] is used to model the frequency dependency of the resistance.

(1)

where:

is the harmonic order

is the resulting positive sequence resistance for harmonic order

is the positive sequence resistance at fundamental frequency

are factors used to represent the skin effect (are used to provide acceptable estimates)

The resulting frequency-dependency characteristics for cable positive sequence resistance is shown in Table 9. Further, the summary of all the cables modeled is given in Table 10.

Table 8 Cable Type parameters

| **Name** | **Rated Voltage (kV)** | **Rated Current (kA)** | **Nominal Frequency (Hz)** | **R'(AC,20°C) (Ohm/km)** | **X' (Ohm/km)** | **R0'(AC) (Ohm/km)** | **X0' (Ohm/km)** | **C' (uF/km)** | **C0' (uF/km)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 220 kV 1C AL\_630sqmm | 220 | 0.705 | 50 | 0.0393 | 0.1 | 0.0393 | 0.15 | 0.145 | 0.12 |
| 33 kV 1C AL\_630sqmm | 33 | 0.593 | 50 | 0.0629 | 0.123 | 0.312 | 0.0504 | 0.329 | 0.329 |
| 33 kV 1C AL\_240sqmm | 33 | 0.378 | 50 | 0.161 | 0.14 | 0.388 | 0.0655 | 0.222 | 0.222 |
| 33 kV 1C AL\_300sqmm | 33 | 0.421 | 50 | 0.129 | 0.136 | 0.364 | 0.0622 | 0.242 | 0.242 |
| 33 kV 1C AL\_500sqmm | 33 | 0.554 | 50 | 0.0797 | 0.325 | 0.0797 | 0.531 | 0.297 | 0.297 |
| 33 kV 1C AL\_185sqmm | 33 | 0.33 | 50 | 0.211 | 0.145 | 0.428 | 0.0703 | 0.202 | 0.202 |
| 33 kV 1C AL\_50sqmm | 33 | 0.162 | 50 | 0.821 | 0.178 | 1.19 | 0.0997 | 0.134 | 0.134 |
| 33 kV 1C AL\_400sqmm | 33 | 0.475 | 50 | 0.101 | 0.131 | 0.342 | 0.0573 | 0.267 | 0.267 |
| 33 kV 1C AL\_95sqmm | 33 | 0.234 | 50 | 0.41 | 0.159 | 0.613 | 0.0822 | 0.164 | 0.164 |

Table 9 Cable frequency-dependency characteristics

|  |  |  |  |
| --- | --- | --- | --- |
| Harmonic Order | Positive Sequence Resistance r1(h)/r1 | Harmonic Order | Positive Sequence Resistance r1(h)/r1 |
| 0 | 0.902 | 26 | 1.737 |
| 1 | 1. | 27 | 1.758 |
| 2 | 1.057 | 28 | 1.779 |
| 3 | 1.104 | 29 | 1.799 |
| 4 | 1.146 | 30 | 1.819 |
| 5 | 1.185 | 31 | 1.839 |
| 6 | 1.221 | 32 | 1.859 |
| 7 | 1.255 | 33 | 1.878 |
| 8 | 1.287 | 34 | 1.898 |
| 9 | 1.318 | 35 | 1.917 |
| 10 | 1.348 | 36 | 1.936 |
| 11 | 1.377 | 37 | 1.955 |
| 12 | 1.405 | 38 | 1.973 |
| 13 | 1.432 | 39 | 1.992 |
| 14 | 1.458 | 40 | 2.01 |
| 15 | 1.484 | 41 | 2.028 |
| 16 | 1.509 | 42 | 2.046 |
| 17 | 1.534 | 43 | 2.064 |
| 18 | 1.558 | 44 | 2.081 |
| 19 | 1.582 | 45 | 2.099 |
| 20 | 1.605 | 46 | 2.116 |
| 21 | 1.628 | 47 | 2.134 |
| 22 | 1.65 | 48 | 2.151 |
| 23 | 1.672 | 49 | 2.168 |
| 24 | 1.694 | 50 | 2.185 |
| 25 | 1.716 | - | - |

Table 10 Cable Modeling Summary

| **Name** | **Type** | **Terminal i** | **Terminal j** | **No. of parallel lines** | **Length (km)** | **R1 (Ohm)** | **X1 (Ohm)** | **R0 (Ohm)** | **X0 (Ohm)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 220kV Feeder | 220 kV 1C AL\_630sqmm | 220kV\_PoC | TX\_220kV | 1 | 0.2 | 0.00786 | 0.02 | 0.00786 | 0.03 |
| PV FEEDER 1 | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | PV-RMU-32 | 1 | 0.285 | 0.017927 | 0.035055 | 0.08892 | 0.014364 |
| PV FEEDER 2 | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | PV-RMU-26 | 1 | 1.925 | 0.121083 | 0.236775 | 0.6006 | 0.09702 |
| PV FEEDER 3 | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | PV-RMU-25 | 1 | 1.435 | 0.090262 | 0.176505 | 0.44772 | 0.072324 |
| PV FEEDER 4 | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | PV-RMU-24 | 1 | 1.465 | 0.092149 | 0.180195 | 0.45708 | 0.073836 |
| PV FEEDER 5 | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | PV-RMU-27 | 1 | 0.24 | 0.015096 | 0.02952 | 0.07488 | 0.012096 |
| PV FEEDER 6 | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | PV-RMU-21 | 1 | 0.7 | 0.04403 | 0.0861 | 0.2184 | 0.03528 |
| PV CS | 33 kV 1C AL\_630sqmm | 33 kV PV Collection Switchboard | 33kV Termination Structure | 5 | 0.03 | 0.000377 | 0.000738 | 0.001872 | 0.000302 |
| PV-PCU-05-01 | 33 kV 1C AL\_240sqmm | PV-RMU-05 | PV-RMU-01 | 1 | 0.19 | 0.03059 | 0.0266 | 0.07372 | 0.012445 |
| PV-PCU-06-02 | 33 kV 1C AL\_240sqmm | PV-RMU-06 | PV-RMU-02 | 1 | 0.195 | 0.031395 | 0.0273 | 0.07566 | 0.012773 |
| PV-PCU-07-03 | 33 kV 1C AL\_240sqmm | PV-RMU-07 | PV-RMU-03 | 1 | 0.195 | 0.031395 | 0.0273 | 0.07566 | 0.012773 |
| PV-PCU-08-04 | 33 kV 1C AL\_240sqmm | PV-RMU-08 | PV-RMU-04 | 1 | 0.2 | 0.0322 | 0.028 | 0.0776 | 0.0131 |
| PV-PCU-09-05 | 33 kV 1C AL\_240sqmm | PV-RMU-09 | PV-RMU-05 | 1 | 0.26 | 0.04186 | 0.0364 | 0.10088 | 0.01703 |
| PV-PCU-10-06 | 33 kV 1C AL\_240sqmm | PV-RMU-10 | PV-RMU-06 | 1 | 0.16 | 0.02576 | 0.0224 | 0.06208 | 0.01048 |
| PV-PCU-11-07 | 33 kV 1C AL\_240sqmm | PV-RMU-11 | PV-RMU-07 | 1 | 0.26 | 0.04186 | 0.0364 | 0.10088 | 0.01703 |
| PV-PCU-12-08 | 33 kV 1C AL\_240sqmm | PV-RMU-12 | PV-RMU-08 | 1 | 0.255 | 0.041055 | 0.0357 | 0.09894 | 0.016703 |
| PV-PCU-13-09 | 33 kV 1C AL\_240sqmm | PV-RMU-13 | PV-RMU-09 | 1 | 0.195 | 0.031395 | 0.0273 | 0.07566 | 0.012773 |
| PV-PCU-14-10 | 33 kV 1C AL\_240sqmm | PV-RMU-14 | PV-RMU-10 | 1 | 0.26 | 0.04186 | 0.0364 | 0.10088 | 0.01703 |
| PV-PCU-15-11 | 33 kV 1C AL\_240sqmm | PV-RMU-15 | PV-RMU-11 | 1 | 0.195 | 0.031395 | 0.0273 | 0.07566 | 0.012773 |
| PV-PCU-16-12 | 33 kV 1C AL\_240sqmm | PV-RMU-16 | PV-RMU-12 | 1 | 0.195 | 0.031395 | 0.0273 | 0.07566 | 0.012773 |
| PV-PCU-17-13 | 33 kV 1C AL\_300sqmm | PV-RMU-17 | PV-RMU-13 | 1 | 0.285 | 0.036765 | 0.03876 | 0.10374 | 0.017727 |
| PV-PCU-18-14 | 33 kV 1C AL\_300sqmm | PV-RMU-18 | PV-RMU-14 | 1 | 0.195 | 0.025155 | 0.02652 | 0.07098 | 0.012129 |
| PV-PCU-19-15 | 33 kV 1C AL\_300sqmm | PV-RMU-19 | PV-RMU-15 | 1 | 0.26 | 0.03354 | 0.03536 | 0.09464 | 0.016172 |
| PV-PCU-20-16 | 33 kV 1C AL\_300sqmm | PV-RMU-20 | PV-RMU-16 | 1 | 0.255 | 0.032895 | 0.03468 | 0.09282 | 0.015861 |
| PV-PCU-21-17 | 33 kV 1C AL\_500sqmm | PV-RMU-21 | PV-RMU-17 | 1 | 0.84 | 0.066948 | 0.273 | 0.066948 | 0.44604 |
| PV-PCU-23-22 | 33 kV 1C AL\_240sqmm | PV-RMU-23 | PV-RMU-22 | 1 | 0.415 | 0.066815 | 0.0581 | 0.16102 | 0.027183 |
| PV-PCU-24-18 | 33 kV 1C AL\_500sqmm | PV-RMU-24 | PV-RMU-18 | 1 | 0.26 | 0.020722 | 0.0845 | 0.020722 | 0.13806 |
| PV-PCU-25-19 | 33 kV 1C AL\_500sqmm | PV-RMU-25 | PV-RMU-19 | 1 | 0.195 | 0.015542 | 0.063375 | 0.015542 | 0.103545 |
| PV-PCU-26-20 | 33 kV 1C AL\_500sqmm | PV-RMU-26 | PV-RMU-20 | 1 | 0.195 | 0.015542 | 0.063375 | 0.015542 | 0.103545 |
| PV-PCU-27-28 | 33 kV 1C AL\_500sqmm | PV-RMU-27 | PV-RMU-28 | 1 | 0.355 | 0.028294 | 0.115375 | 0.028294 | 0.188505 |
| PV-PCU-28-29 | 33 kV 1C AL\_300sqmm | PV-RMU-28 | PV-RMU-29 | 1 | 0.255 | 0.032895 | 0.03468 | 0.09282 | 0.015861 |
| PV-PCU-29-30 | 33 kV 1C AL\_240sqmm | PV-RMU-29 | PV-RMU-30 | 1 | 0.395 | 0.063595 | 0.0553 | 0.15326 | 0.025873 |
| PV-PCU-30-23 | 33 kV 1C AL\_240sqmm | PV-RMU-30 | PV-RMU-23 | 1 | 0.585 | 0.094185 | 0.0819 | 0.22698 | 0.038318 |
| PV-PCU-32-33 | 33 kV 1C AL\_500sqmm | PV-RMU-32 | PV-RMU-33 | 1 | 0.3 | 0.02391 | 0.0975 | 0.02391 | 0.1593 |
| PV-PCU-33-34 | 33 kV 1C AL\_300sqmm | PV-RMU-33 | PV-RMU-34 | 1 | 0.31 | 0.03999 | 0.04216 | 0.11284 | 0.019282 |
| PV-PCU-34-35 | 33 kV 1C AL\_240sqmm | PV-RMU-34 | PV-RMU-35 | 1 | 0.285 | 0.045885 | 0.0399 | 0.11058 | 0.018668 |
| PV-PCU-35-36 | 33 kV 1C AL\_240sqmm | PV-RMU-35 | PV-RMU-36 | 1 | 0.3 | 0.0483 | 0.042 | 0.1164 | 0.01965 |
| PV-PCU-36-31 | 33 kV 1C AL\_240sqmm | PV-RMU-36 | PV-RMU-31 | 1 | 0.13 | 0.02093 | 0.0182 | 0.05044 | 0.008515 |
| BESS-PCU-124-25 | 33 kV 1C AL\_185sqmm | BESS-RMU-24 | BESS-RMU-25 | 1 | 0.01 | 0.00211 | 0.00145 | 0.00428 | 0.000703 |
| BESS-PCU-35-36 | 33 kV 1C AL\_240sqmm | BESS-RMU-35 | BESS-RMU-36 | 1 | 0.01 | 0.00161 | 0.0014 | 0.00388 | 0.000655 |
| BESS-PCU-33-34 | 33 kV 1C AL\_50sqmm | BESS-RMU-33 | BESS-RMU-34 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-08-09 | 33 kV 1C AL\_400sqmm | BESS-RMU-08 | BESS-RMU-09 | 1 | 0.01 | 0.00101 | 0.00131 | 0.00342 | 0.000573 |
| BESS-PCU-22-23 | 33 kV 1C AL\_400sqmm | BESS-RMU-22 | BESS-RMU-23 | 1 | 0.01 | 0.00101 | 0.00131 | 0.00342 | 0.000573 |
| BESS-PCU-15-16 | 33 kV 1C AL\_400sqmm | BESS-RMU-15 | BESS-RMU-16 | 1 | 0.01 | 0.00101 | 0.00131 | 0.00342 | 0.000573 |
| BESS CS | 33 kV 1C AL\_630sqmm | 33kV BESS Collection Station | 33kV Termination Structure | 5 | 0.03 | 0.000377 | 0.000738 | 0.001872 | 0.000302 |
| BESS-PCU-04-05 | 33 kV 1C AL\_95sqmm | BESS-RMU-04 | BESS-RMU-05 | 1 | 0.01 | 0.0041 | 0.00159 | 0.00613 | 0.000822 |
| BESS-PCU-23-24 | 33 kV 1C AL\_240sqmm | BESS-RMU-23 | BESS-RMU-24 | 1 | 0.01 | 0.00161 | 0.0014 | 0.00388 | 0.000655 |
| BESS-PCU-19-20 | 33 kV 1C AL\_50sqmm | BESS-RMU-19 | BESS-RMU-20 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS FEEDER 2 | 33 kV 1C AL\_630sqmm | 33kV BESS Collection Station | BESS-RMU-08 | 1 | 0.01 | 0.000629 | 0.00123 | 0.00312 | 0.000504 |
| BESS-PCU-09-10 | 33 kV 1C AL\_240sqmm | BESS-RMU-09 | BESS-RMU-10 | 1 | 0.01 | 0.00161 | 0.0014 | 0.00388 | 0.000655 |
| BESS-PCU-10-11 | 33 kV 1C AL\_185sqmm | BESS-RMU-10 | BESS-RMU-11 | 1 | 0.01 | 0.00211 | 0.00145 | 0.00428 | 0.000703 |
| BESS-PCU-18-19 | 33 kV 1C AL\_95sqmm | BESS-RMU-18 | BESS-RMU-19 | 1 | 0.01 | 0.0041 | 0.00159 | 0.00613 | 0.000822 |
| BESS-PCU-26-27 | 33 kV 1C AL\_50sqmm | BESS-RMU-26 | BESS-RMU-27 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-05-06 | 33 kV 1C AL\_50sqmm | BESS-RMU-05 | BESS-RMU-06 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-11-12 | 33 kV 1C AL\_95sqmm | BESS-RMU-11 | BESS-RMU-12 | 1 | 0.01 | 0.0041 | 0.00159 | 0.00613 | 0.000822 |
| BESS FEEDER 4 | 33 kV 1C AL\_630sqmm | 33kV BESS Collection Station | BESS-RMU-22 | 1 | 0.01 | 0.000629 | 0.00123 | 0.00312 | 0.000504 |
| BESS-PCU-17-18 | 33 kV 1C AL\_185sqmm | BESS-RMU-17 | BESS-RMU-18 | 1 | 0.01 | 0.00211 | 0.00145 | 0.00428 | 0.000703 |
| BESS-PCU-16-17 | 33 kV 1C AL\_240sqmm | BESS-RMU-16 | BESS-RMU-17 | 1 | 0.01 | 0.00161 | 0.0014 | 0.00388 | 0.000655 |
| BESS-PCU-12-13 | 33 kV 1C AL\_50sqmm | BESS-RMU-12 | BESS-RMU-13 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS FEEDER 3 | 33 kV 1C AL\_630sqmm | 33kV BESS Collection Station | BESS-RMU-15 | 1 | 0.01 | 0.000629 | 0.00123 | 0.00312 | 0.000504 |
| BESS-PCU-25-26 | 33 kV 1C AL\_95sqmm | BESS-RMU-25 | BESS-RMU-26 | 1 | 0.01 | 0.0041 | 0.00159 | 0.00613 | 0.000822 |
| BESS-PCU-36-37 | 33 kV 1C AL\_185sqmm | BESS-RMU-36 | BESS-RMU-37 | 1 | 0.01 | 0.00211 | 0.00145 | 0.00428 | 0.000703 |
| BESS-PCU-32-33 | 33 kV 1C AL\_50sqmm | BESS-RMU-32 | BESS-RMU-33 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS FEEDER 6 | 33 kV 1C AL\_400sqmm | 33kV BESS Collection Station | BESS-RMU-35 | 1 | 0.01 | 0.00101 | 0.00131 | 0.00342 | 0.000573 |
| BESS-PCU-37-38 | 33 kV 1C AL\_95sqmm | BESS-RMU-37 | BESS-RMU-38 | 1 | 0.01 | 0.0041 | 0.00159 | 0.00613 | 0.000822 |
| BESS-PCU-30-31 | 33 kV 1C AL\_185sqmm | BESS-RMU-30 | BESS-RMU-31 | 1 | 0.01 | 0.00211 | 0.00145 | 0.00428 | 0.000703 |
| BESS-PCU-29-30 | 33 kV 1C AL\_240sqmm | BESS-RMU-29 | BESS-RMU-30 | 1 | 0.01 | 0.00161 | 0.0014 | 0.00388 | 0.000655 |
| BESS-PCU-31-32 | 33 kV 1C AL\_95sqmm | BESS-RMU-31 | BESS-RMU-32 | 1 | 0.01 | 0.0041 | 0.00159 | 0.00613 | 0.000822 |
| BESS FEEDER 5 | 33 kV 1C AL\_400sqmm | 33kV BESS Collection Station | BESS-RMU-29 | 1 | 0.01 | 0.00101 | 0.00131 | 0.00342 | 0.000573 |
| BESS FEEDER 1 | 33 kV 1C AL\_630sqmm | 33kV BESS Collection Station | BESS-RMU-01 | 1 | 0.01 | 0.000629 | 0.00123 | 0.00312 | 0.000504 |
| BESS-PCU-01-02 | 33 kV 1C AL\_400sqmm | BESS-RMU-01 | BESS-RMU-02 | 1 | 0.01 | 0.00101 | 0.00131 | 0.00342 | 0.000573 |
| BESS-PCU-39-40 | 33 kV 1C AL\_50sqmm | BESS-RMU-39 | BESS-RMU-40 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-02-03 | 33 kV 1C AL\_240sqmm | BESS-RMU-02 | BESS-RMU-03 | 1 | 0.01 | 0.00161 | 0.0014 | 0.00388 | 0.000655 |
| BESS-PCU-03-04 | 33 kV 1C AL\_185sqmm | BESS-RMU-03 | BESS-RMU-04 | 1 | 0.01 | 0.00211 | 0.00145 | 0.00428 | 0.000703 |
| BESS-PCU-38-39 | 33 kV 1C AL\_50sqmm | BESS-RMU-38 | BESS-RMU-39 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-06-07 | 33 kV 1C AL\_50sqmm | BESS-RMU-06 | BESS-RMU-07 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-13-14 | 33 kV 1C AL\_50sqmm | BESS-RMU-13 | BESS-RMU-14 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-27-28 | 33 kV 1C AL\_50sqmm | BESS-RMU-27 | BESS-RMU-28 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| BESS-PCU-20-21 | 33 kV 1C AL\_50sqmm | BESS-RMU-20 | BESS-RMU-21 | 1 | 0.01 | 0.00821 | 0.00178 | 0.0119 | 0.000997 |
| 33kV TS | 33 kV 1C AL\_630sqmm | TX\_33kV | 33kV Termination Structure | 5 | 0.03 | 0.000377 | 0.000738 | 0.001872 | 0.000302 |

## Norton Equivalent of Inverters (PV and BESS)

Inverter harmonic current injection models and harmonic-impedance characteristics were created for both PV and BESS inverters based on data provided by SMA (Appendices 9.6 to 9.8). Different inverter operation modes were considered in this study including “Q at Night” mode for PV inverters and charging/discharging mode for BESS. For each harmonic order, the maximum harmonic current emissions among different power output levels were used as a conservative approach.

The harmonic impedance characteristics for both inverters are shown in Tables 11-12. Based on the data provided by SMA, the BESS discharging operation impedance characteristics are the same as the PV inverters.

Table 11 SCS 4200 UP Harmonic Impedance Characteristics

| **h** | **f [Hz]** | **R [Ohm] (used in PowerFactory Model1)** | **X [Ohm] (used in PowerFactory Model1)** | **UThevenin [VRMS]** | **G [mSiemens]** | **B [mSiemens]** | **INorton [mA]** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 100 | 2.00 | 188.78 | 11.1 | 0.0561 | -5.2966 | 58.8 |
| 3 | 150 | 2.12 | 287.17 | 10.55 | 0.0257 | -3.482 | 36.75 |
| 4 | 200 | 2.39 | 390.80 | 22.98 | 0.0157 | -2.5587 | 58.8 |
| 5 | 250 | 2.97 | 502.23 | 77.52 | 0.0118 | -1.991 | 154.35 |
| 6 | 300 | 4.12 | 624.96 | 13.78 | 0.0105 | -1.6 | 22.05 |
| 7 | 350 | 6.32 | 764.06 | 123.55 | 0.0108 | -1.3087 | 161.7 |
| 8 | 400 | 10.53 | 927.34 | 61.35 | 0.0122 | -1.0782 | 66.15 |
| 9 | 450 | 18.67 | 1127.67 | 16.58 | 0.0147 | -0.8865 | 14.7 |
| 10 | 500 | 35.17 | 1388.04 | 102.05 | 0.0182 | -0.72 | 73.5 |
| 11 | 550 | 71.38 | 1754.02 | 193.54 | 0.0232 | -0.5692 | 110.25 |
| 12 | 600 | 162.82 | 2329.96 | 34.33 | 0.0298 | -0.4271 | 14.7 |
| 13 | 650 | 461.73 | 3411.90 | 303.67 | 0.039 | -0.2878 | 88.2 |
| 14 | 700 | 2160.39 | 6104.44 | 333.16 | 0.0515 | -0.1456 | 51.45 |
| 15 | 750 | 14329.12 | -1234.04 | 422.84 | 0.0693 | 0.006 | 29.4 |
| 16 | 800 | 2401.60 | -4413.20 | 184.64 | 0.0951 | 0.1748 | 36.75 |
| 17 | 850 | 858.16 | -2376.74 | 74.29 | 0.1344 | 0.3722 | 29.4 |
| 18 | 900 | 472.44 | -1473.38 | 22.74 | 0.1973 | 0.6154 | 14.7 |
| 19 | 950 | 317.20 | -967.59 | 29.94 | 0.3059 | 0.9332 | 29.4 |
| 20 | 1000 | 237.87 | -637.88 | 25.02 | 0.5132 | 1.3763 | 36.75 |
| 21 | 1050 | 191.16 | -400.56 | 6.52 | 0.9704 | 2.0334 | 14.7 |
| 22 | 1100 | 160.95 | -217.58 | 7.96 | 2.1973 | 2.9705 | 29.4 |
| 23 | 1150 | 140.09 | -69.23 | 5.74 | 5.7371 | 2.8354 | 36.75 |
| 24 | 1200 | 124.95 | 55.69 | 2.01 | 6.6767 | -2.976 | 14.7 |
| 25 | 1250 | 113.55 | 164.03 | 7.33 | 2.853 | -4.1214 | 36.75 |
| 26 | 1300 | 104.70 | 260.18 | 10.31 | 1.3311 | -3.3078 | 36.75 |
| 27 | 1350 | 97.66 | 347.11 | 7.95 | 0.7511 | -2.6696 | 22.05 |
| 28 | 1400 | 91.96 | 426.89 | 19.26 | 0.4822 | -2.2386 | 44.1 |
| 29 | 1450 | 87.25 | 501.01 | 37.38 | 0.3374 | -1.9372 | 73.5 |
| 30 | 1500 | 83.31 | 570.56 | 16.95 | 0.2506 | -1.7161 | 29.4 |
| 31 | 1550 | 79.97 | 636.38 | 37.71 | 0.1944 | -1.547 | 58.8 |
| 32 | 1600 | 77.12 | 699.10 | 51.7 | 0.1559 | -1.4132 | 73.5 |
| 33 | 1650 | 74.65 | 759.22 | 11.21 | 0.1283 | -1.3045 | 14.7 |
| 34 | 1700 | 72.50 | 817.14 | 24.12 | 0.1077 | -1.2142 | 29.4 |
| 35 | 1750 | 70.61 | 873.17 | 45.07 | 0.092 | -1.1378 | 51.45 |
| 36 | 1800 | 68.94 | 927.57 | 6.84 | 0.0797 | -1.0722 | 7.35 |
| 37 | 1850 | 67.46 | 980.56 | 21.67 | 0.0698 | -1.015 | 22.05 |
| 38 | 1900 | 66.14 | 1032.31 | 38.02 | 0.0618 | -0.9647 | 36.75 |
| 39 | 1950 | 64.95 | 1082.98 | 7.97 | 0.0552 | -0.9201 | 7.35 |
| 40 | 2000 | 63.88 | 1132.67 | 25.02 | 0.0496 | -0.8801 | 22.05 |
| 41 | 2050 | 62.91 | 1181.51 | 34.79 | 0.0449 | -0.844 | 29.4 |
| 42 | 2100 | 62.03 | 1229.57 | 9.05 | 0.0409 | -0.8112 | 7.35 |
| 43 | 2150 | 61.22 | 1276.95 | 18.79 | 0.0375 | -0.7813 | 14.7 |
| 44 | 2200 | 60.49 | 1323.70 | 29.22 | 0.0345 | -0.7539 | 22.05 |
| 45 | 2250 | 59.81 | 1369.89 | 10.08 | 0.0318 | -0.7286 | 7.35 |
| 46 | 2300 | 59.19 | 1415.56 | 31.24 | 0.0295 | -0.7052 | 22.05 |
| 47 | 2350 | 58.62 | 1460.77 | 32.24 | 0.0274 | -0.6835 | 22.05 |
| 48 | 2400 | 58.09 | 1505.54 | 11.07 | 0.0256 | -0.6632 | 7.35 |
| 49 | 2450 | 57.60 | 1549.93 | 34.2 | 0.0239 | -0.6443 | 22.05 |
| 50 | 2500 | 57.14 | 1593.96 | 46.89 | 0.0225 | -0.6266 | 29.4 |

1 per unit impedance entered in PowerFactory for harmonic-impedance frequency dependency is calculated as , where

Table 12 SC 3600 UP XT (BESS Inverters) Charge Mode Harmonic Impedance Characteristics

| **h** | **f [Hz]** | **R [Ohm] (used in PowerFactory Model1)** | **X [Ohm] (used in PowerFactory Model1)** | **UThevenin [VRMS]** | **G [mSiemens]** | **B [mSiemens]** | **INorton [mA]** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 100 | 2.00 | 188.78 | 8.33 | 0.0561 | -5.2966 | 44.10 |
| 3 | 150 | 2.12 | 287.17 | 10.55 | 0.0257 | -3.4820 | 36.75 |
| 4 | 200 | 2.39 | 390.80 | 20.11 | 0.0157 | -2.5587 | 51.45 |
| 5 | 250 | 2.97 | 502.23 | 81.21 | 0.0118 | -1.9910 | 161.70 |
| 6 | 300 | 4.12 | 624.96 | 18.37 | 0.0105 | -1.6000 | 29.40 |
| 7 | 350 | 6.32 | 764.06 | 146.02 | 0.0108 | -1.3087 | 191.10 |
| 8 | 400 | 10.53 | 927.34 | 136.33 | 0.0122 | -1.0782 | 147.00 |
| 9 | 450 | 18.67 | 1127.67 | 16.58 | 0.0147 | -0.8865 | 14.70 |
| 10 | 500 | 35.17 | 1388.04 | 122.46 | 0.0182 | -0.7200 | 88.20 |
| 11 | 550 | 71.38 | 1754.02 | 232.25 | 0.0232 | -0.5692 | 132.30 |
| 12 | 600 | 162.82 | 2329.96 | 51.50 | 0.0298 | -0.4271 | 22.05 |
| 13 | 650 | 461.73 | 3411.90 | 379.59 | 0.0390 | -0.2878 | 110.25 |
| 14 | 700 | 2160.39 | 6104.44 | 380.76 | 0.0515 | -0.1456 | 58.80 |
| 15 | 750 | 14329.12 | -1234.04 | 317.13 | 0.0693 | 0.0060 | 22.05 |
| 16 | 800 | 2401.60 | -4413.20 | 258.50 | 0.0951 | 0.1748 | 51.45 |
| 17 | 850 | 858.16 | -2376.74 | 111.14 | 0.1344 | 0.3722 | 44.10 |
| 18 | 900 | 472.44 | -1473.38 | 22.74 | 0.1973 | 0.6154 | 14.70 |
| 19 | 950 | 317.20 | -967.59 | 44.91 | 0.3059 | 0.9332 | 44.10 |
| 20 | 1000 | 237.87 | -637.88 | 25.02 | 0.5132 | 1.3763 | 36.75 |
| 21 | 1050 | 191.16 | -400.56 | 6.52 | 0.9704 | 2.0334 | 14.70 |
| 22 | 1100 | 160.95 | -217.58 | 9.95 | 2.1973 | 2.9705 | 36.75 |
| 23 | 1150 | 140.09 | -69.23 | 6.89 | 5.7371 | 2.8354 | 44.10 |
| 24 | 1200 | 124.95 | 55.69 | 2.01 | 6.6767 | -2.9760 | 14.70 |
| 25 | 1250 | 113.55 | 164.03 | 11.73 | 2.8530 | -4.1214 | 58.80 |
| 26 | 1300 | 104.70 | 260.18 | 16.49 | 1.3311 | -3.3078 | 58.80 |
| 27 | 1350 | 97.66 | 347.11 | 5.30 | 0.7511 | -2.6696 | 14.70 |
| 28 | 1400 | 91.96 | 426.89 | 28.89 | 0.4822 | -2.2386 | 66.15 |
| 29 | 1450 | 87.25 | 501.01 | 22.43 | 0.3374 | -1.9372 | 44.10 |
| 30 | 1500 | 83.31 | 570.56 | 12.71 | 0.2506 | -1.7161 | 22.05 |
| 31 | 1550 | 79.97 | 638.38 | 70.71 | 0.1944 | -1.5470 | 110.25 |
| 32 | 1600 | 77.12 | 699.10 | 62.03 | 0.1559 | -1.4132 | 88.20 |
| 33 | 1650 | 74.65 | 759.22 | 22.43 | 0.1283 | -1.3045 | 29.40 |
| 34 | 1700 | 72.50 | 817.14 | 72.35 | 0.1077 | -1.2142 | 88.20 |
| 35 | 1750 | 70.61 | 873.17 | 25.75 | 0.0920 | -1.1378 | 29.40 |
| 36 | 1800 | 68.94 | 927.57 | 13.67 | 0.0797 | -1.0722 | 14.70 |
| 37 | 1850 | 67.46 | 980.56 | 43.35 | 0.0698 | -1.0150 | 44.10 |
| 38 | 1900 | 66.14 | 1032.31 | 22.81 | 0.0618 | -0.9647 | 22.05 |
| 39 | 1950 | 64.95 | 1082.98 | 7.97 | 0.0552 | -0.9201 | 7.35 |
| 40 | 2000 | 63.88 | 1132.67 | 41.69 | 0.0496 | -0.8801 | 36.75 |
| 41 | 2050 | 62.91 | 1181.51 | 26.09 | 0.0449 | -0.8440 | 22.05 |
| 42 | 2100 | 62.03 | 1229.57 | 9.05 | 0.0409 | -0.8112 | 7.35 |
| 43 | 2150 | 61.22 | 1276.95 | 37.59 | 0.0375 | -0.7813 | 29.40 |
| 44 | 2200 | 60.49 | 1323.70 | 29.22 | 0.0345 | -0.7539 | 22.05 |
| 45 | 2250 | 59.81 | 1369.89 | 10.08 | 0.0318 | -0.7286 | 7.35 |
| 46 | 2300 | 59.19 | 1415.56 | 31.24 | 0.0295 | -0.7052 | 22.05 |
| 47 | 2350 | 58.62 | 1460.77 | 42.98 | 0.0274 | -0.6835 | 29.40 |
| 48 | 2400 | 58.09 | 1505.54 | 22.15 | 0.0256 | -0.6632 | 14.70 |
| 49 | 2450 | 57.60 | 1549.93 | 45.60 | 0.0239 | -0.6443 | 29.40 |
| 50 | 2500 | 57.14 | 1593.96 | 58.62 | 0.0225 | -0.6266 | 36.75 |

1 per unit impedance entered in PowerFactory for harmonic-impedance frequency dependency is calculated as , where

# Access Standard Requirement

Below shows the NER Clause S5.2.5.2 – Quality of Electricity Generated [4].

**Automatic access standard**

(b) The *automatic access standard* is a *generating system* when generating and when not generating must not produce at any of its *connection points* for *generation*:

(1) *voltage* fluctuation greater than the limits allocated by the *Network* *Service* *Provider* under clause S5.1.5(a);

(2) harmonic *voltage* distortion greater than the emission limits specified by a *plant* *standard* under paragraph (a) or allocated by the *Network* *Service* *Provider* under clause S5.1.6(a); and

(3) *voltage* unbalance greater than the limits allocated by the *Network* *Service* *Provider* in accordance with clause S5.1.7(c).

**Minimum access standard**

(c) The *minimum* *access* *standard* is a *generating* *system* when generating and when not generating must not produce at any of its *connection* *points* for *generation*:

(1) *voltage* fluctuations greater than limits determined under clause S5.1.5(b);

(2) harmonic *voltage* distortion more than the lesser of the emission limits determined by the relevant *Network* *Service* *Provider* under clause S5.1.6(b) and specified by a *plant* *standard* under paragraph (a); and

(3) *voltage* unbalance more than limits determined under clause S5.1.7(c).

**Negotiated access standard**

(d) A *negotiated* *access* *standard* negotiated under this clause S5.2.5.2 must not prevent the *Network* *Service* *Provider* meeting the *system* *standards* or contractual obligations to existing *Network* *Users*.

The aim of this report is to assess compliance with NER Clause S5.2.5.2(b)(2).

# Study Execution

This chapter outlines the harmonic emission assessment criteria and the methodology employed by the proposed generator to fulfill the criteria.

## Methodology

The Power Quality and Harmonic Analysis module in PowerFactory is used to determine the worst-case voltage distortion at the 220 kV PoC for HSFBESS.

The built-in impedance loci script in PowerFactory is used to perform iterative harmonic load flow calculation based on R-X values, within the area defined by the harmonic-impedance polygon, resulting in the highest voltage harmonic distortion at each harmonic frequency.

IEC 61000-3-6-2008 general summation law as defined in equation (2) is applied to the contributing harmonic sources to calculate the total harmonic voltage at the POC.

(2)

where:

is the magnitude of the resulting harmonic voltage (order h), for the considered aggregation of sources

is the magnitude of the various individual emission levels (order h) to be combined

α is the summation exponent for harmonics. This is also the degree to which individual harmonic voltages vary randomly in terms of magnitude and phase

Summation exponent for harmonics (α) used in the calculation done automatically by PowerFactory are set to 1 for all harmonic orders in this study. These α values consider that harmonic currents from the PV and BESS inverters are in phase and no cancellation will occur.

## Compliance Assessment

Figure 2 shows a simplified representation of the external network and the proposed generator. It shows that the external network can be represented by a voltage source behind a Thevenin equivalent impedance. and are obtained from the TNSP-defined background harmonic voltages and harmonic-impedance polygons. On the other hand, the proposed generator (HSFBESS) can be represented as a Norton equivalent impedance and an ideal current source (.

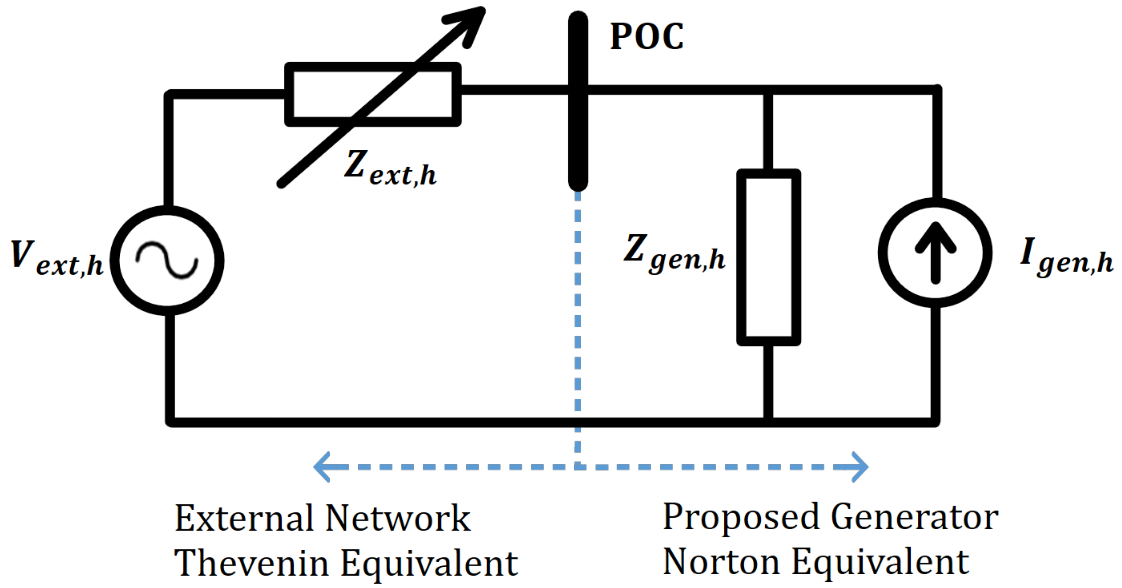


Figure 2 Simplified representation of the external network and the proposed generator

Based on Figure 2, the total harmonic voltage distortion at the POC can be separated into two components: *V1,h* and *V2,h* which represents voltage harmonic distortion coming from the external network and from the proposed generator (HSFBESS), respectively.

*V1,h* and *V2,h* can be calculated as follows:

(3)

(4)

The total voltage harmonic distortion at the POC () can be calculated by summing the contributions coming from the external network and from the proposed generator by applying the general summation law as described in equation (2):

(5)

To determine the proposed generator contribution to the total voltage harmonic distortion at the POC (), the pre-connection background harmonic voltages must be subtracted from the post-connection total voltage harmonic distortion at the POC ().

(6)

and are evaluated against the Planning and Allocations limits respectively. To achieve compliance, these values should not exceed the TNSP-defined limits shown in Table 13.

Table 13 Planning and Allocation Limits for HSFBESS at 220 kV POC

| **Harmonic Order** | **Planning Limits (%)** | **Allocation Limits (%) - AAS** |
| --- | --- | --- |
| 2 | 1.400 | 0.10 |
| 3 | 2.000 | 0.10 |
| 4 | 0.800 | 0.10 |
| 5 | 2.000 | 0.17 |
| 6 | 0.400 | 0.10 |
| 7 | 2.000 | 0.17 |
| 8 | 0.400 | 0.10 |
| 9 | 1.000 | 0.10 |
| 10 | 0.350 | 0.10 |
| 11 | 1.500 | 0.27 |
| 12 | 0.318 | 0.10 |
| 13 | 1.500 | 0.27 |
| 14 | 0.296 | 0.10 |
| 15 | 0.300 | 0.10 |
| 16 | 0.279 | 0.10 |
| 17 | 1.200 | 0.18 |
| 18 | 0.266 | 0.10 |
| 19 | 1.074 | 0.18 |
| 20 | 0.255 | 0.10 |
| 21 | 0.200 | 0.10 |
| 22 | 0.246 | 0.10 |
| 23 | 0.887 | 0.13 |
| 24 | 0.239 | 0.10 |
| 25 | 0.816 | 0.13 |
| 26 | 0.233 | 0.10 |
| 27 | 0.200 | 0.10 |
| 28 | 0.228 | 0.10 |
| 29 | 0.703 | 0.11 |
| 30 | 0.223 | 0.10 |
| 31 | 0.658 | 0.11 |
| 32 | 0.219 | 0.10 |
| 33 | 0.200 | 0.10 |
| 34 | 0.216 | 0.10 |
| 35 | 0.583 | 0.10 |
| 36 | 0.213 | 0.10 |
| 37 | 0.551 | 0.10 |
| 38 | 0.210 | 0.10 |
| 39 | 0.200 | 0.10 |
| 40 | 0.208 | 0.10 |
| 41 | 0.498 | 0.10 |
| 42 | 0.205 | 0.10 |
| 43 | 0.474 | 0.10 |
| 44 | 0.203 | 0.10 |
| 45 | 0.200 | 0.10 |
| 46 | 0.201 | 0.10 |
| 47 | 0.434 | 0.10 |
| 48 | 0.200 | 0.10 |
| 49 | 0.416 | 0.10 |
| 50 | 0.198 | 0.10 |

Another requirement from the TNSP to assess the harmonic effects of the proposed generator is to compute for the maximum levels of amplification of the existing harmonic voltages. The Amplification Factor (AF) is defined as the measure of how the pre-connection background harmonic voltages are amplified after connecting the passive components (transformers, cables, and harmonic filters) of the generating system (with harmonic current source, , equal to zero). Mathematically, it is defined by equation (7).

(7)

An AF greater than one means that the generator amplifies the existing background harmonic voltages. Conversely, an AF less than one means that the generator attenuates the existing background harmonic voltages.

# Calculation Study Results

This chapter shows the results of harmonic-voltage contribution calculation study at the proposed connection point for all scenarios considered covering all harmonic orders. Table 14 describes the details of all the operation scenarios considered.

Table 14 Scenario Description – All Scenarios without harmonic filters

| Scenario name | Description | Inverter Characteristic |
| --- | --- | --- |
| PQ01a | Pmax Qmax\_100%P PV\_100%Q BESS | BESS Discharging |
| PQ02a | Pmax Qmin\_100%P PV\_100%Q BESS | BESS Discharging |
| PQ03a | Pmax Qmax\_50%P PV\_50%Q BESS | BESS Discharging |
| PQ04a | Pmax Qmin\_50%P PV\_50%Q BESS | BESS Discharging |
| PQ05a | Pmin Qmax\_100%P BESS\_100%Q PV | BESS Charging |
| PQ06a | Pmin Qmin\_100%P BESS\_100%Q PV | BESS Charging |
| PQ07a | 01a+BESS Coll Fdr1 Outage | BESS Discharging |
| PQ08a | 02a+BESS Coll Fdr1 Outage | BESS Discharging |
| PQ09a | 03a+BESS Coll Fdr1 Outage | BESS Discharging |
| PQ10a | 04a+BESS Coll Fdr1 Outage | BESS Discharging |
| PQ11a | 05a+BESS Coll Fdr1 Outage | BESS Charging |
| PQ12a | 06a+BESS Coll Fdr1 Outage | BESS Charging |
| PQ13a | 01a+PV Coll Fdr2 Outage | BESS Discharging |
| PQ14a | 02a+PV Coll Fdr2 Outage | BESS Discharging |
| PQ15a | 03a+PV Coll Fdr2 Outage | BESS Discharging |
| PQ16a | 04a+PV Coll Fdr2 Outage | BESS Discharging |
| PQ17a | 05a+PV Coll Fdr2 Outage | BESS Charging |
| PQ18a | 06a+PV Coll Fdr2 Outage | BESS Charging |
| PQ19a | 01a\_+10%TX\_Z | BESS Discharging |
| PQ20a | 02a\_+10%TX\_Z | BESS Discharging |
| PQ21a | 03a\_+10%TX\_Z | BESS Discharging |
| PQ22a | 04a\_+10%TX\_Z | BESS Discharging |
| PQ23a | 05a\_+10%TX\_Z | BESS Charging |
| PQ24a | 06a\_+10%TX\_Z | BESS Charging |
| PQ25a | 01a\_-10%TX\_Z | BESS Discharging |
| PQ26a | 02a\_-10%TX\_Z | BESS Discharging |
| PQ27a | 03a\_-10%TX\_Z | BESS Discharging |
| PQ28a | 04a\_-10%TX\_Z | BESS Discharging |
| PQ29a | 05a\_-10%TX\_Z | BESS Charging |
| PQ30a | 06a\_-10%TX\_Z | BESS Charging |
| PQ31a | Pmax\_Qmax\_PV Only | BESS Discharging |
| PQ32a | Pmax\_Qmin\_PV Only | BESS Discharging |
| PQ33a | Pmax\_Qmax\_BESS Only | BESS Discharging |
| PQ34a | Pmax\_Qmin\_BESS Only | BESS Discharging |
| PQ35a | Pmin\_Qmax\_BESS Only | BESS Charging |
| PQ36a | Pmin\_Qmin\_BESS Only | BESS Charging |
| PQ37a | Qmax\_Night | PV Inverter Q at Night |
| PQ38a | Qmin\_Night | PV Inverter Q at Night |

Figure 3 shows the maximum total voltage harmonic distortion (for all scenarios considered) at the POC evaluated against the planning limits. Compliance is not achieved for the THD and harmonic orders 16, 28, 35, 38, 40, 44, 46, 47, and 50.

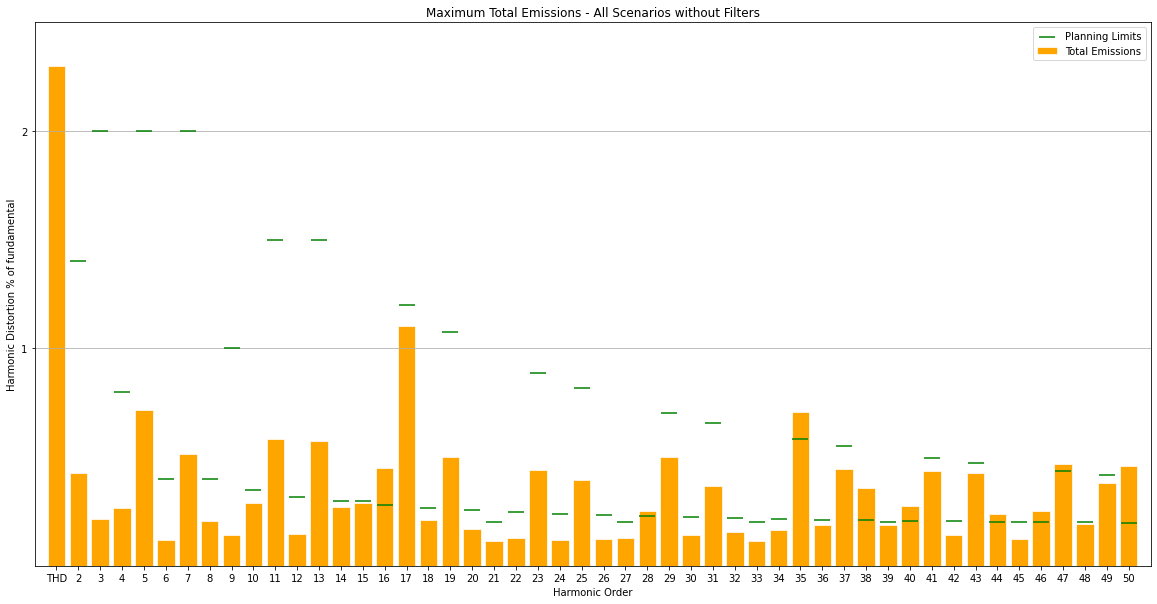


Figure 3 Maximum Total emissions at the POC and Planning limits for all scenarios without harmonic filters

Figure 4 shows the voltage harmonic contribution from HSFBESS (*V2,h*) evaluated against the allocation limits. Compliance is not achieved for the THD and harmonic orders 7, 10, 11, 13, 14, 15, 16, 17, 28, 29, 35, 37, 38, 40, 41, 43, 44, 46, 47, 49, and 50.

A graph of blue and orange bars

Description automatically generated

Figure 4 Maximum HSFBESS emissions at the POC and Allocation limits for all scenarios without harmonic filters

Figure 5 illustrates the amplification factors for all harmonic orders and shows significant amplification on some harmonic orders.

A graph showing a line of blue lines

Description automatically generated with medium confidence

Figure 5 Maximum and Minimum Amplification factor for scenarios without harmonic filters

A summary of these calculations results are tabulated in Table 15 along with the corresponding external impedance (*Rext,h* and *Xext,h*) that resulted to worst case voltage harmonic distortion at the POC.

Table 15 Calculation results summary – without harmonic filters

| **Harmonic Order** | **Maximum Total Emissions** | **Planning Limits (%)** | **Maximum Plant Emissions** | **Allocation Limits (%) - AAS** | **Maximum Amplification Factor** | **Rext,h resulting to maximum total emissions**  **(Ohm)** | **Xext,h resulting to maximum total emissions**  **(Ohm)** | **Scenario corresponding to maximum total emissions** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.427232 | 1.400 | 0 | 0.10 | 0.83 | 24.36581 | 66.31245 | PQ31a |
| 3 | 0.213011 | 2.000 | 0 | 0.10 | 0.85 | 47.46036 | 92.05799 | PQ31a |
| 4 | 0.266096 | 0.800 | 0.07 | 0.10 | 1.16 | 79.32044 | -66.5943 | PQ37a |
| 5 | 0.718774 | 2.000 | 0.01 | 0.17 | 0.95 | 86.19292 | 47.51453 | PQ31a |
| 6 | 0.119613 | 0.400 | 0.02 | 0.10 | 0.94 | 166.9864 | 73.95929 | PQ37a |
| 7 | 0.512848 | 2.000 | 0.17 | 0.17 | 0.90 | 326.4539 | 145.3214 | PQ25a |
| 8 | 0.204039 | 0.400 | 0.08 | 0.10 | 0.98 | 169.8991 | 160.8185 | PQ29a |
| 9 | 0.140035 | 1.000 | 0.02 | 0.10 | 1.00 | 229.8472 | 195.4188 | PQ37a |
| 10 | 0.290681 | 0.350 | 0.2 | 0.10 | 0.94 | 455.1025 | 313.3798 | PQ29a |
| 11 | 0.584097 | 1.500 | 0.41 | 0.27 | 0.98 | 602.9901 | 30.5986 | PQ29a |
| 12 | 0.144777 | 0.318 | 0.07 | 0.10 | 1.02 | 481.954 | 300.9019 | PQ37a |
| 13 | 0.575897 | 1.500 | 0.39 | 0.27 | 1.01 | 533.3305 | 166.5788 | PQ29a |
| 14 | 0.270089 | 0.296 | 0.2 | 0.10 | 1.04 | 346.6753 | 161.487 | PQ23a |
| 15 | 0.288889 | 0.300 | 0.14 | 0.10 | 1.11 | 245.2851 | 209.8812 | PQ19a |
| 16 | 0.447713 | 0.279 | 0.31 | 0.10 | 1.37 | 53.29403 | 228.452 | PQ23a |
| 17 | 1.103183 | 1.200 | 0.5 | 0.18 | 1.55 | 73.40891 | 309.1026 | PQ31a |
| 18 | 0.210197 | 0.266 | 0.08 | 0.10 | 1.18 | 186.9029 | 392.3875 | PQ33a |
| 19 | 0.499213 | 1.074 | 0 | 0.18 | 0.86 | 189.0749 | 30.39575 | PQ23a |
| 20 | 0.167598 | 0.255 | 0.04 | 0.10 | 1.03 | 160.8698 | -97.7469 | PQ25a |
| 21 | 0.116096 | 0.200 | 0.02 | 0.10 | 1.07 | 258.5588 | -74.2148 | PQ37a |
| 22 | 0.129001 | 0.246 | 0.01 | 0.10 | 0.99 | 258.8016 | -41.1202 | PQ29a |
| 23 | 0.442175 | 0.887 | 0 | 0.13 | 1.00 | 112.1761 | -23.7363 | PQ19a |
| 24 | 0.117308 | 0.239 | 0 | 0.10 | 0.96 | 132.2868 | 44.55857 | PQ37a |
| 25 | 0.394887 | 0.816 | 0 | 0.13 | 0.95 | 168.284 | 81.31618 | PQ23a |
| 26 | 0.124981 | 0.233 | 0.01 | 0.10 | 0.92 | 339.9109 | 134.78 | PQ23a |
| 27 | 0.12916 | 0.200 | 0.03 | 0.10 | 1.02 | 523.8008 | -200.955 | PQ37a |
| 28 | 0.249745 | 0.228 | 0.14 | 0.10 | 1.07 | 1326.363 | -778.533 | PQ29a |
| 29 | 0.499809 | 0.703 | 0.15 | 0.11 | 1.17 | 378.6369 | -487.038 | PQ25a |
| 30 | 0.140647 | 0.223 | 0.03 | 0.10 | 1.03 | 338.2805 | -214.57 | PQ25a |
| 31 | 0.367623 | 0.658 | 0.04 | 0.11 | 1.02 | 107.1728 | -117.306 | PQ29a |
| 32 | 0.156524 | 0.219 | 0.05 | 0.10 | 1.00 | 170.8238 | 106.3554 | PQ31a |
| 33 | 0.112145 | 0.200 | 0.01 | 0.10 | 1.00 | 210.227 | 84.25389 | PQ31a |
| 34 | 0.163916 | 0.216 | 0.06 | 0.10 | 1.10 | 97.71763 | 305.2863 | PQ31a |
| 35 | 0.707111 | 0.583 | 0.42 | 0.10 | 1.45 | 82.64092 | 763.3384 | PQ31a |
| 36 | 0.185835 | 0.213 | 0.08 | 0.10 | 0.95 | 1563.78 | 578.5465 | PQ37a |
| 37 | 0.443801 | 0.551 | 0.17 | 0.10 | 1.17 | 1301.568 | 399.2984 | PQ11a |
| 38 | 0.359372 | 0.210 | 0.25 | 0.10 | 1.35 | 174.6758 | 397.9659 | PQ31a |
| 39 | 0.188141 | 0.200 | 0.09 | 0.10 | 1.30 | 139.8682 | 420.3075 | PQ31a |
| 40 | 0.274953 | 0.208 | 0.17 | 0.10 | 1.13 | 579.7625 | 657.5352 | PQ11a |
| 41 | 0.434172 | 0.498 | 0.19 | 0.10 | 0.98 | 1079.816 | 171.5544 | PQ07a |
| 42 | 0.141911 | 0.205 | 0.04 | 0.10 | 1.04 | 590.6077 | 278.9369 | PQ07a |
| 43 | 0.424687 | 0.474 | 0.19 | 0.10 | 1.01 | 1203.322 | 301.0402 | PQ29a |
| 44 | 0.23799 | 0.203 | 0.14 | 0.10 | 1.31 | 60.17078 | -429.43 | PQ31a |
| 45 | 0.121226 | 0.200 | 0.02 | 0.10 | 1.09 | 100.1733 | -213.735 | PQ31a |
| 46 | 0.253397 | 0.201 | 0.15 | 0.10 | 1.14 | 169.7253 | 235.9401 | PQ07a |
| 47 | 0.466877 | 0.434 | 0.25 | 0.10 | 0.99 | 1005.158 | 198.4451 | PQ23a |
| 48 | 0.193779 | 0.200 | 0.09 | 0.10 | 1.06 | 426.2675 | 254.1204 | PQ29a |
| 49 | 0.380452 | 0.416 | 0.17 | 0.10 | 0.99 | 686.9746 | 62.31492 | PQ23a |
| 50 | 0.458559 | 0.198 | 0.36 | 0.10 | 1.10 | 94.98764 | -464.735 | PQ05a |

# Harmonic Filter Concept Design

Considering the results of calculations, it is necessary to perform harmonic filter design to mitigate excessive voltage harmonic levels and achieve compliance with the planning and allocation limits. Four harmonic filters are proposed with the following ratings:

Table 16 Proposed Harmonic Filters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Name** | **Terminal** | **Rated Reactive Power (Mvar)** | **Tuning Order** | **Quality Factor** |
| HF1 | 33kV BESS Collection Station | 1 | 28.5 | 40 |
| HF2 | 33kV BESS Collection Station | 3 | 7.5 | 2.2 |
| HF3 | 33 kV PV Collection Switchboard | 6 | 7.5 | 2.2 |
| HF4 | 34 kV PV Collection Switchboard | 2 | 28.9 | 40 |

More details of the harmonic filters are provided in Figures 6-9.

A screenshot of a computer

Description automatically generated

Figure 6 HF1 Filter Parameters

A screenshot of a computer

Description automatically generated

Figure 7 HF2 Filter Parameters

A screenshot of a computer

Description automatically generated

Figure 8 HF3 Filter Parameters

A screenshot of a computer

Description automatically generated

Figure 9 HF4 Filter Parameters

All scenarios considered in Chapter 5 were repeated to include the harmonic filters in service and the same calculation methodology was applied. Table 17 describes the details of all the scenarios where the harmonic filters are in service.

Table 17 Scenario Description – All Scenarios with harmonic filters in service

| Scenario name | Description | BESS Inverter Characteristic |
| --- | --- | --- |
| PQ01b | PQ01a with Harmonic Filters in service | Discharging |
| PQ02b | PQ02a with Harmonic Filters in service | Discharging |
| PQ03b | PQ03a with Harmonic Filters in service | Discharging |
| PQ04b | PQ04a with Harmonic Filters in service | Discharging |
| PQ05b | PQ05a with Harmonic Filters in service | Charging |
| PQ06b | PQ06a with Harmonic Filters in service | Charging |
| PQ07b | PQ07a with Harmonic Filters in service | Discharging |
| PQ08b | PQ08a with Harmonic Filters in service | Discharging |
| PQ09b | PQ09a with Harmonic Filters in service | Discharging |
| PQ10b | PQ10a with Harmonic Filters in service | Discharging |
| PQ11b | PQ11a with Harmonic Filters in service | Charging |
| PQ12b | PQ12a with Harmonic Filters in service | Charging |
| PQ13b | PQ13a with Harmonic Filters in service | Discharging |
| PQ14b | PQ14a with Harmonic Filters in service | Discharging |
| PQ15b | PQ15a with Harmonic Filters in service | Discharging |
| PQ16b | PQ16a with Harmonic Filters in service | Discharging |
| PQ17b | PQ17a with Harmonic Filters in service | Charging |
| PQ18b | PQ18a with Harmonic Filters in service | Charging |
| PQ19b | PQ19a with Harmonic Filters in service | Discharging |
| PQ20b | PQ20a with Harmonic Filters in service | Discharging |
| PQ21b | PQ21a with Harmonic Filters in service | Discharging |
| PQ22b | PQ22a with Harmonic Filters in service | Discharging |
| PQ23b | PQ23a with Harmonic Filters in service | Charging |
| PQ24b | PQ24a with Harmonic Filters in service | Charging |
| PQ25b | PQ25a with Harmonic Filters in service | Discharging |
| PQ26b | PQ26a with Harmonic Filters in service | Discharging |
| PQ27b | PQ27a with Harmonic Filters in service | Discharging |
| PQ28b | PQ28a with Harmonic Filters in service | Discharging |
| PQ29b | PQ29a with Harmonic Filters in service | Charging |
| PQ30b | PQ30a with Harmonic Filters in service | Charging |
| PQ31b | PQ31a with Harmonic Filters in service | BESS Discharging |
| PQ32b | PQ32a with Harmonic Filters in service | BESS Discharging |
| PQ33b | PQ33a with Harmonic Filters in service | BESS Discharging |
| PQ34b | PQ34a with Harmonic Filters in service | BESS Discharging |
| PQ35b | PQ35a with Harmonic Filters in service | BESS Charging |
| PQ36b | PQ36a with Harmonic Filters in service | BESS Charging |
| PQ37b | PQ37a with Harmonic Filters in service | PV Inverter Q at Night |
| PQ38b | PQ38a with Harmonic Filters in service | PV Inverter Q at Night |

As shown in Figures 10 and 11, with the application of filters, the generating plant is now able to achieve compliance in both planning and allocation limits.

A graph with orange and green lines

Description automatically generated

Figure 10 Maximum Total emissions at the POC and Planning limits for all scenarios with harmonic filters in service

A graph of a graph

Description automatically generated with medium confidence

Figure 1 Maximum HSFBESS emissions at the POC and Allocation limits for all scenarios with harmonic filters in service

Further, with the application of harmonic filters, the amplification factors are now closer to unity as shown in Figure 12.

A graph with blue lines

Description automatically generated

Figure 2 Maximum and Minimum Amplification factor for scenarios with harmonic filters in service

A summary of these calculations results are tabulated in Table 18 along with the corresponding external impedance (*Rext,h* and *Xext,h*) that resulted to worst case voltage harmonic distortion at the POC.

The proposed filters were assessed considering the following component tolerances:

* Capacitance variation: ±2%
* Inductance variation: ±1%
* Resistance variation: ±5%

Table 18 Calculation results summary - with harmonic filters in service

| **Harmonic Order** | **Maximum Total Emissions** | **Planning Limits (%)** | **Maximum Plant Emissions** | **Allocation Limits (%) - AAS** | **Maximum Amplification Factor** | **Rext,h resulting to maximum total emissions**  **(Ohm)** | **Xext,h resulting to maximum total emissions**  **(Ohm)** | **Scenario corresponding to maximum total emissions** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.431866 | 1.400 | 0 | 0.10 | 0.84 | 24.36581 | 66.31245 | PQ31b |
| 3 | 0.218991 | 2.000 | 0 | 0.10 | 0.87 | 47.46036 | 92.05799 | PQ31b |
| 4 | 0.264076 | 0.800 | 0.07 | 0.10 | 1.12 | 79.32044 | -66.5943 | PQ37b |
| 5 | 0.804033 | 2.000 | 0.09 | 0.17 | 0.95 | 91.78038 | 209.1755 | PQ31b |
| 6 | 0.163022 | 0.400 | 0.06 | 0.10 | 0.98 | 219.5287 | 251.7933 | PQ37b |
| 7 | 0.432143 | 2.000 | 0.09 | 0.17 | 0.78 | 326.4554 | 174.2604 | PQ33b |
| 8 | 0.173485 | 0.400 | 0.05 | 0.10 | 0.83 | 169.8991 | 160.8185 | PQ35b |
| 9 | 0.122889 | 1.000 | 0 | 0.10 | 0.96 | 107.8319 | -13.5008 | PQ37b |
| 10 | 0.182166 | 0.350 | 0.09 | 0.10 | 0.75 | 455.1025 | 313.3798 | PQ29b |
| 11 | 0.357445 | 1.500 | 0.18 | 0.27 | 0.81 | 602.5549 | 29.63104 | PQ29b |
| 12 | 0.101011 | 0.318 | 0.03 | 0.10 | 1.04 | 388.1021 | -166.762 | PQ37b |
| 13 | 0.349684 | 1.500 | 0.16 | 0.27 | 0.83 | 530.2087 | 13.78881 | PQ29b |
| 14 | 0.167702 | 0.296 | 0.1 | 0.10 | 0.88 | 346.6753 | -112.564 | PQ29b |
| 15 | 0.17927 | 0.300 | 0.03 | 0.10 | 0.99 | 108.7554 | 209.8812 | PQ33b |
| 16 | 0.206103 | 0.279 | 0.07 | 0.10 | 1.05 | 53.29403 | 228.452 | PQ35b |
| 17 | 0.67829 | 1.200 | 0.08 | 0.18 | 0.97 | 73.40891 | 309.1026 | PQ35b |
| 18 | 0.128729 | 0.266 | 0 | 0.10 | 0.92 | 152.6345 | 8.843457 | PQ37b |
| 19 | 0.508195 | 1.074 | 0 | 0.18 | 0.91 | 189.0749 | 30.39575 | PQ23b |
| 20 | 0.154489 | 0.255 | 0.03 | 0.10 | 1.06 | 160.8698 | -97.7469 | PQ25b |
| 21 | 0.110925 | 0.200 | 0.01 | 0.10 | 1.07 | 216.9862 | -74.0729 | PQ37b |
| 22 | 0.127236 | 0.246 | 0 | 0.10 | 0.99 | 214.8968 | -41.1202 | PQ35b |
| 23 | 0.442453 | 0.887 | 0 | 0.13 | 1.00 | 112.1761 | -23.7363 | PQ01b |
| 24 | 0.117089 | 0.239 | 0 | 0.10 | 0.96 | 132.2868 | 44.55857 | PQ37b |
| 25 | 0.392374 | 0.816 | 0 | 0.13 | 0.94 | 168.284 | 81.31618 | PQ23b |
| 26 | 0.130901 | 0.233 | 0.01 | 0.10 | 0.88 | 566.9826 | 362.0556 | PQ35b |
| 27 | 0.114458 | 0.200 | 0.01 | 0.10 | 1.03 | 446.3257 | -200.955 | PQ37b |
| 28 | 0.190308 | 0.228 | 0.08 | 0.10 | 1.60 | 159.9078 | -700.068 | PQ29b |
| 29 | 0.459586 | 0.703 | 0.11 | 0.11 | 1.30 | 178.3138 | -487.038 | PQ25b |
| 30 | 0.123491 | 0.223 | 0.01 | 0.10 | 1.11 | 56.55485 | -214.57 | PQ25b |
| 31 | 0.350481 | 0.658 | 0.02 | 0.11 | 1.05 | 23.51912 | -117.306 | PQ29b |
| 32 | 0.115605 | 0.219 | 0.01 | 0.10 | 1.01 | 170.8238 | 45.41216 | PQ35b |
| 33 | 0.101541 | 0.200 | 0 | 0.10 | 0.99 | 199.2648 | 50.17197 | PQ35b |
| 34 | 0.12099 | 0.216 | 0.01 | 0.10 | 0.99 | 97.71763 | 305.2863 | PQ35b |
| 35 | 0.290077 | 0.583 | 0 | 0.10 | 0.98 | 195.1018 | 129.5252 | PQ33b |
| 36 | 0.119453 | 0.213 | 0.01 | 0.10 | 1.06 | 99.44161 | -265.492 | PQ29b |
| 37 | 0.301052 | 0.551 | 0.03 | 0.10 | 0.99 | 1288.088 | 138.0983 | PQ35b |
| 38 | 0.156168 | 0.210 | 0.05 | 0.10 | 1.13 | 471.698 | -694.995 | PQ25b |
| 39 | 0.116077 | 0.200 | 0.02 | 0.10 | 1.08 | 215.2742 | -619.086 | PQ37b |
| 40 | 0.12429 | 0.208 | 0.02 | 0.10 | 1.01 | 579.7625 | 657.5352 | PQ35b |
| 41 | 0.267805 | 0.498 | 0.02 | 0.10 | 1.02 | 1080.578 | 100.0548 | PQ01b |
| 42 | 0.102048 | 0.205 | 0 | 0.10 | 1.00 | 590.6077 | 278.9369 | PQ19b |
| 43 | 0.26244 | 0.474 | 0.03 | 0.10 | 0.99 | 1203.322 | 301.0402 | PQ35b |
| 44 | 0.115448 | 0.203 | 0.01 | 0.10 | 0.99 | 218.1641 | -429.43 | PQ25b |
| 45 | 0.101973 | 0.200 | 0 | 0.10 | 1.00 | 100.1733 | -213.735 | PQ25b |
| 46 | 0.11216 | 0.201 | 0.01 | 0.10 | 1.01 | 169.7253 | 235.9401 | PQ31b |
| 47 | 0.248612 | 0.434 | 0.03 | 0.10 | 0.96 | 1005.158 | 198.4451 | PQ29b |
| 48 | 0.109233 | 0.200 | 0.01 | 0.10 | 1.00 | 486.3521 | 254.1204 | PQ35b |
| 49 | 0.231943 | 0.416 | 0.02 | 0.10 | 0.97 | 686.9746 | 62.31492 | PQ29b |
| 50 | 0.125455 | 0.198 | 0.03 | 0.10 | 1.02 | 194.3115 | -464.735 | PQ29b |

# Conclusion

A harmonic assessment was conducted by OX2 Australia based on NER requirement clause S5.2.5.2 and the harmonic limits specified by AEMO. The findings of the assessment are summarised below:

* With the connection of HSFBESS, the voltage harmonic distortion at the POC exceeds the planning and AAS allocation limits for several orders. Orders 7, 10, 11, 13, 14, 15, 16, 17, 28, 29, 35, 37, 38, 40, 41, 43, 44, 46, 47, 49, and 50 were found to exceed the limits. Moreover, significant amplification at the POC was observed with the connection of the generating system, with the 17th order having the maximum amplification factor at 1.55.
* To reduce the harmonic emissions at the POC, four different harmonic filters are proposed, and the calculation study was repeated to consider the effects of filters.
* With the harmonic filters in service, the harmonic emissions comply with the planning and allocation limits. Also, the amplification factors at the POC were alleviated and are closer to unity for the complete frequency range.

# References

[1] IEC61000.3.6-2012 - Limits - Assessment of Emission limits for the connection of distorting installation to MV, HV and EHV power systems

[2] AS/NZS 61000.3.6:2012. Electromagnetic Compatibility (EMC) - Limits - Assessment of emission limits for distorting loads in MV and HV power systems.

[3] Network modelling for harmonic studies, Cigre, Reference:766, April 2019

[4] DIgSILENT PowerFactory Version 2023 User Manual, January 2023

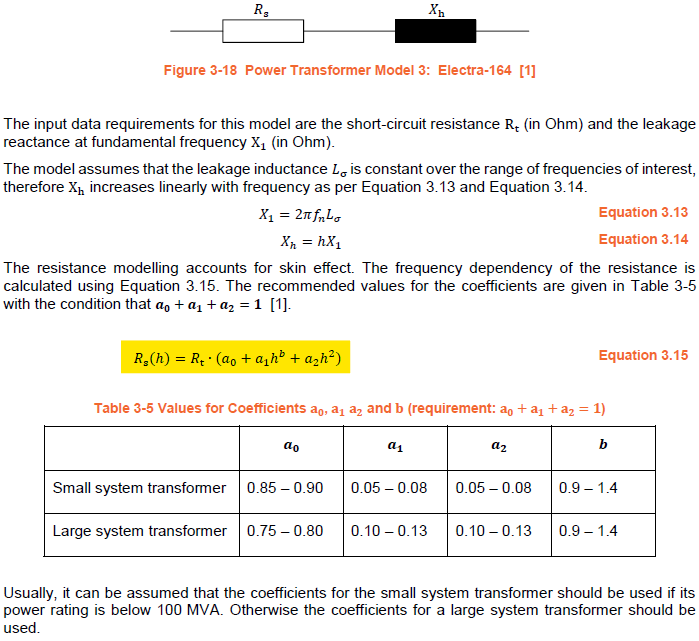
[5] Attachment 3 - Harmonic Assessment Requirements Guide v1.0.pdf

[6] AEMC, "National Electricity Rules, Version 204," December 5, 2023.

[7] Power Grid Solutions Pty Ltd “Horsham Solar Farm Power Quality Study Report PRJ23-15-RPT-01B”, May 2023

# Appendices

## Main Transformer Frequency-dependency characteristics reference



## Load Flow Summary

Load flow results and output of each inverter for each scenario considered.

### Without harmonic filters

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario name | POC MW | POC MVar | No. of active BESS Inv | No. of active PV Inv | BESS kW | BESS kVar | PV kW | PV kVar |
| PQ01a | 119 | 47 | 40 | 36 | 0 | 1701 | 3322 | 0 |
| PQ02a | 119 | -47 | 40 | 36 | 0 | -661 | 3323 | 0 |
| PQ03a | 119 | 47 | 40 | 36 | 1493 | 847 | 1659 | 941 |
| PQ04a | 119 | -47 | 40 | 36 | 1493 | -335 | 1659 | -373 |
| PQ05a | -100 | 47 | 40 | 36 | -2492 | 0 | 0 | 1766 |
| PQ06a | -100 | -47 | 40 | 36 | -2493 | 0 | 0 | -863 |
| PQ07a | 119 | 47 | 40 | 36 | 0 | 1701 | 3322 | 0 |
| PQ08a | 119 | -47 | 40 | 36 | 0 | -661 | 3323 | 0 |
| PQ09a | 119 | 47 | 40 | 36 | 1493 | 847 | 1659 | 941 |
| PQ10a | 119 | -47 | 40 | 36 | 1493 | -335 | 1659 | -373 |
| PQ11a | -100 | 47 | 40 | 36 | -2492 | 0 | 0 | 1766 |
| PQ12a | -100 | -47 | 40 | 36 | -2493 | 0 | 0 | -863 |
| PQ13a | 119 | 47 | 40 | 30 | 0 | 1703 | 3987 | 0 |
| PQ14a | 119 | -47 | 40 | 30 | 0 | -659 | 3988 | 0 |
| PQ15a | 119 | 47 | 40 | 30 | 1493 | 847 | 1991 | 1130 |
| PQ16a | 119 | -47 | 40 | 30 | 1493 | -335 | 1990 | -447 |
| PQ17a | -100 | 47 | 40 | 30 | -2491 | 0 | 0 | 2121 |
| PQ18a | -100 | -47 | 40 | 30 | -2493 | 0 | 0 | -1035 |
| PQ19a | 119 | 47 | 40 | 36 | 0 | 1742 | 3323 | 0 |
| PQ20a | 119 | -47 | 40 | 36 | 0 | -621 | 3324 | 0 |
| PQ21a | 119 | 47 | 40 | 36 | 1493 | 867 | 1659 | 964 |
| PQ22a | 119 | -47 | 40 | 36 | 1493 | -315 | 1659 | -350 |
| PQ23a | -100 | 47 | 40 | 36 | -2491 | 0 | 0 | 1801 |
| PQ24a | -100 | -47 | 40 | 36 | -2492 | 0 | 0 | -830 |
| PQ25a | 119 | 47 | 40 | 36 | 0 | 1660 | 3321 | 0 |
| PQ26a | 119 | -47.01 | 40 | 36 | 0 | -701 | 3322 | 0 |
| PQ27a | 119 | 47 | 40 | 36 | 1492 | 826 | 1658 | 918 |
| PQ28a | 119 | -47.01 | 40 | 36 | 1492 | -355 | 1658 | -395 |
| PQ29a | -100 | 47 | 40 | 36 | -2492 | 0 | 0 | 1731 |
| PQ30a | -100 | -47 | 40 | 36 | -2493 | 0 | 0 | -896 |
| PQ31a | 119 | 47 | 0 | 36 | 0 | 0 | 3324 | 1837 |
| PQ32a | 119 | -47 | 0 | 36 | 0 | 0 | 3323 | -785 |
| PQ33a | 100 | 47 | 40 | 0 | 2507 | 1578 | 0 | 0 |
| PQ34a | 100 | -47 | 40 | 0 | 2507 | -788 | 0 | 0 |
| PQ35a | -100 | 47 | 40 | 0 | -2493 | 1578 | 0 | 0 |
| PQ36a | -100 | -47 | 40 | 0 | -2493 | -788 | 0 | 0 |
| PQ37a | 0 | 47 | 40 | 36 | 0 | 0 | 3 | 1489 |
| PQ38a | 0 | -47.01 | 40 | 36 | 0 | 0 | 2 | -1137 |

### With harmonic filters in service

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Scenario name | POC MW | POC MVar | No. of active BESS Inv | No. of active PV Inv | BESS kW | BESS kVar | PV kW | PV kVar |
| PQ01b | 119 | 47 | 40 | 36 | 0 | 1366 | 3322 | 0 |
| PQ02b | 119 | -47 | 40 | 36 | 0 | -940 | 3323 | 0 |
| PQ03b | 119 | 47 | 40 | 36 | 1493 | 679 | 1659 | 754 |
| PQ04b | 119 | -47 | 40 | 36 | 1493 | -475 | 1659 | -528 |
| PQ05b | -100 | 47 | 40 | 36 | -2492 | 0 | 0 | 1396 |
| PQ06b | -100 | -47 | 40 | 36 | -2492 | 0 | 0 | -1168 |
| PQ07b | 119 | 47 | 40 | 36 | 0 | 1366 | 3322 | 0 |
| PQ08b | 119 | -47 | 40 | 36 | 0 | -940 | 3323 | 0 |
| PQ09b | 119 | 47 | 40 | 36 | 1493 | 679 | 1659 | 754 |
| PQ10b | 119 | -47 | 40 | 36 | 1493 | -475 | 1659 | -528 |
| PQ11b | -100 | 47 | 40 | 36 | -2492 | 0 | 0 | 1396 |
| PQ12b | -100 | -47 | 40 | 36 | -2492 | 0 | 0 | -1168 |
| PQ13b | 119 | 47 | 40 | 30 | 0 | 1368 | 3987 | 0 |
| PQ14b | 119 | -47 | 40 | 30 | 0 | -938 | 3988 | 0 |
| PQ15b | 119 | 47 | 40 | 30 | 1493 | 679 | 1991 | 906 |
| PQ16b | 119 | -47 | 40 | 30 | 1493 | -475 | 1991 | -633 |
| PQ17b | -100 | 47 | 40 | 30 | -2492 | 0 | 0 | 1677 |
| PQ18b | -100 | -47 | 40 | 30 | -2492 | 0 | 0 | -1401 |
| PQ19b | 119 | 47 | 40 | 36 | 0 | 1403 | 3323 | 0 |
| PQ20b | 119 | -47.01 | 40 | 36 | 0 | -898 | 3324 | 0 |
| PQ21b | 119 | 47 | 40 | 36 | 1493 | 697 | 1659 | 775 |
| PQ22b | 119 | -47.01 | 40 | 36 | 1493 | -454 | 1659 | -505 |
| PQ23b | -100 | 47 | 40 | 36 | -2491 | 0 | 0 | 1427 |
| PQ24b | -100 | -47.01 | 40 | 36 | -2492 | 0 | 0 | -1132 |
| PQ25b | 119 | 47 | 40 | 36 | 0 | 1328 | 3321 | 0 |
| PQ26b | 119 | -47 | 40 | 36 | 0 | -982 | 3322 | 0 |
| PQ27b | 119 | 47 | 40 | 36 | 1492 | 660 | 1658 | 733 |
| PQ28b | 119 | -47 | 40 | 36 | 1492 | -496 | 1658 | -551 |
| PQ29b | -100 | 47 | 40 | 36 | -2493 | 0 | 0 | 1366 |
| PQ30b | -100 | -47 | 40 | 36 | -2493 | 0 | 0 | -1203 |
| PQ31b | 119 | 47 | 0 | 36 | 0 | 0 | 3323 | 1587 |
| PQ32b | 119 | -47 | 0 | 36 | 0 | 0 | 3323 | -991 |
| PQ33b | 100 | 47 | 40 | 0 | 2507 | 1467 | 0 | 0 |
| PQ34b | 100 | -47 | 40 | 0 | 2507 | -880 | 0 | 0 |
| PQ35b | -100 | 47 | 40 | 0 | -2493 | 1468 | 0 | 0 |
| PQ36b | -100 | -47 | 40 | 0 | -2493 | -880 | 0 | 0 |
| PQ37b | 0 | 47 | 40 | 36 | 0 | 0 | 2 | 1122 |
| PQ38b | 0 | -47 | 40 | 36 | 0 | 0 | 3 | -1440 |

## Total Emissions

The total voltage harmonic distortion at the POC for each scenario considered.

### Without harmonic filters

| **Harmonic Order** | **PQ01a** | **PQ02a** | **PQ03a** | **PQ04a** | **PQ05a** | **PQ06a** | **PQ07a** | **PQ08a** | **PQ09a** | **PQ10a** | **PQ11a** | **PQ12a** | **PQ13a** | **PQ14a** | **PQ15a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 2.2182 | 2.2182 | 2.2182 | 2.2182 | 2.2810 | 2.2810 | 2.1989 | 2.1989 | 2.1989 | 2.1989 | 2.2512 | 2.2512 | 2.1576 | 2.1576 | 2.1576 |
| 2 | 0.3914 | 0.3914 | 0.3914 | 0.3914 | 0.3889 | 0.3889 | 0.3960 | 0.3960 | 0.3960 | 0.3960 | 0.3937 | 0.3937 | 0.3950 | 0.3950 | 0.3950 |
| 3 | 0.1978 | 0.1978 | 0.1978 | 0.1978 | 0.1966 | 0.1966 | 0.1998 | 0.1998 | 0.1998 | 0.1998 | 0.1987 | 0.1987 | 0.1992 | 0.1992 | 0.1992 |
| 4 | 0.2620 | 0.2620 | 0.2620 | 0.2620 | 0.2581 | 0.2581 | 0.2588 | 0.2588 | 0.2588 | 0.2588 | 0.2554 | 0.2554 | 0.2590 | 0.2590 | 0.2590 |
| 5 | 0.7115 | 0.7115 | 0.7115 | 0.7115 | 0.7085 | 0.7085 | 0.7126 | 0.7126 | 0.7126 | 0.7126 | 0.7100 | 0.7100 | 0.7110 | 0.7110 | 0.7110 |
| 6 | 0.1052 | 0.1052 | 0.1052 | 0.1052 | 0.1080 | 0.1080 | 0.1053 | 0.1053 | 0.1053 | 0.1053 | 0.1077 | 0.1077 | 0.1049 | 0.1049 | 0.1049 |
| 7 | 0.5082 | 0.5082 | 0.5082 | 0.5082 | 0.5082 | 0.5082 | 0.5049 | 0.5049 | 0.5049 | 0.5049 | 0.5049 | 0.5049 | 0.4989 | 0.4989 | 0.4989 |
| 8 | 0.1729 | 0.1729 | 0.1729 | 0.1729 | 0.2014 | 0.2014 | 0.1708 | 0.1708 | 0.1708 | 0.1708 | 0.1961 | 0.1961 | 0.1696 | 0.1696 | 0.1696 |
| 9 | 0.1297 | 0.1297 | 0.1297 | 0.1297 | 0.1297 | 0.1297 | 0.1292 | 0.1292 | 0.1292 | 0.1292 | 0.1292 | 0.1292 | 0.1291 | 0.1291 | 0.1291 |
| 10 | 0.2671 | 0.2671 | 0.2671 | 0.2671 | 0.2860 | 0.2860 | 0.2624 | 0.2624 | 0.2624 | 0.2624 | 0.2789 | 0.2789 | 0.2542 | 0.2542 | 0.2542 |
| 11 | 0.5623 | 0.5623 | 0.5623 | 0.5623 | 0.5751 | 0.5751 | 0.5462 | 0.5462 | 0.5462 | 0.5462 | 0.5572 | 0.5572 | 0.5308 | 0.5308 | 0.5308 |
| 12 | 0.1177 | 0.1177 | 0.1177 | 0.1177 | 0.1306 | 0.1306 | 0.1165 | 0.1165 | 0.1165 | 0.1165 | 0.1277 | 0.1277 | 0.1125 | 0.1125 | 0.1125 |
| 13 | 0.5586 | 0.5586 | 0.5586 | 0.5586 | 0.5737 | 0.5737 | 0.5397 | 0.5397 | 0.5397 | 0.5397 | 0.5527 | 0.5527 | 0.5171 | 0.5171 | 0.5171 |
| 14 | 0.2550 | 0.2550 | 0.2550 | 0.2550 | 0.2679 | 0.2679 | 0.2436 | 0.2436 | 0.2436 | 0.2436 | 0.2544 | 0.2544 | 0.2303 | 0.2303 | 0.2303 |
| 15 | 0.2846 | 0.2846 | 0.2846 | 0.2846 | 0.2695 | 0.2695 | 0.2761 | 0.2761 | 0.2761 | 0.2761 | 0.2635 | 0.2635 | 0.2620 | 0.2620 | 0.2620 |
| 16 | 0.4139 | 0.4139 | 0.4139 | 0.4139 | 0.4357 | 0.4357 | 0.3929 | 0.3929 | 0.3929 | 0.3929 | 0.4105 | 0.4105 | 0.3467 | 0.3467 | 0.3467 |
| 17 | 0.5171 | 0.5171 | 0.5171 | 0.5171 | 0.5378 | 0.5378 | 0.5495 | 0.5495 | 0.5495 | 0.5495 | 0.5680 | 0.5680 | 0.6727 | 0.6727 | 0.6727 |
| 18 | 0.1245 | 0.1245 | 0.1245 | 0.1245 | 0.1245 | 0.1245 | 0.1207 | 0.1207 | 0.1207 | 0.1207 | 0.1207 | 0.1207 | 0.1185 | 0.1185 | 0.1185 |
| 19 | 0.4817 | 0.4817 | 0.4817 | 0.4817 | 0.4857 | 0.4857 | 0.4736 | 0.4736 | 0.4736 | 0.4736 | 0.4774 | 0.4774 | 0.4684 | 0.4684 | 0.4684 |
| 20 | 0.1661 | 0.1661 | 0.1661 | 0.1661 | 0.1661 | 0.1661 | 0.1652 | 0.1652 | 0.1652 | 0.1652 | 0.1652 | 0.1652 | 0.1657 | 0.1657 | 0.1657 |
| 21 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1098 |
| 22 | 0.1258 | 0.1258 | 0.1258 | 0.1258 | 0.1288 | 0.1288 | 0.1256 | 0.1256 | 0.1256 | 0.1256 | 0.1283 | 0.1283 | 0.1255 | 0.1255 | 0.1255 |
| 23 | 0.4421 | 0.4421 | 0.4421 | 0.4421 | 0.4421 | 0.4421 | 0.4418 | 0.4418 | 0.4418 | 0.4418 | 0.4418 | 0.4418 | 0.4417 | 0.4417 | 0.4417 |
| 24 | 0.1160 | 0.1160 | 0.1160 | 0.1160 | 0.1160 | 0.1160 | 0.1159 | 0.1159 | 0.1159 | 0.1159 | 0.1159 | 0.1159 | 0.1159 | 0.1159 | 0.1159 |
| 25 | 0.3910 | 0.3910 | 0.3910 | 0.3910 | 0.3926 | 0.3926 | 0.3911 | 0.3911 | 0.3911 | 0.3911 | 0.3926 | 0.3926 | 0.3910 | 0.3910 | 0.3910 |
| 26 | 0.1221 | 0.1221 | 0.1221 | 0.1221 | 0.1248 | 0.1248 | 0.1223 | 0.1223 | 0.1223 | 0.1223 | 0.1248 | 0.1248 | 0.1218 | 0.1218 | 0.1218 |
| 27 | 0.1181 | 0.1181 | 0.1181 | 0.1181 | 0.1152 | 0.1152 | 0.1180 | 0.1180 | 0.1180 | 0.1180 | 0.1154 | 0.1154 | 0.1173 | 0.1173 | 0.1173 |
| 28 | 0.2242 | 0.2242 | 0.2242 | 0.2242 | 0.2428 | 0.2428 | 0.2247 | 0.2247 | 0.2247 | 0.2247 | 0.2416 | 0.2416 | 0.2188 | 0.2188 | 0.2188 |
| 29 | 0.4832 | 0.4832 | 0.4832 | 0.4832 | 0.4647 | 0.4647 | 0.4800 | 0.4800 | 0.4800 | 0.4800 | 0.4632 | 0.4632 | 0.4770 | 0.4770 | 0.4770 |
| 30 | 0.1379 | 0.1379 | 0.1379 | 0.1379 | 0.1348 | 0.1348 | 0.1377 | 0.1377 | 0.1377 | 0.1377 | 0.1349 | 0.1349 | 0.1362 | 0.1362 | 0.1362 |
| 31 | 0.3573 | 0.3573 | 0.3573 | 0.3573 | 0.3641 | 0.3641 | 0.3567 | 0.3567 | 0.3567 | 0.3567 | 0.3630 | 0.3630 | 0.3556 | 0.3556 | 0.3556 |
| 32 | 0.1436 | 0.1436 | 0.1436 | 0.1436 | 0.1454 | 0.1454 | 0.1447 | 0.1447 | 0.1447 | 0.1447 | 0.1463 | 0.1463 | 0.1404 | 0.1404 | 0.1404 |
| 33 | 0.1070 | 0.1070 | 0.1070 | 0.1070 | 0.1114 | 0.1114 | 0.1074 | 0.1074 | 0.1074 | 0.1074 | 0.1116 | 0.1116 | 0.1061 | 0.1061 | 0.1061 |
| 34 | 0.1347 | 0.1347 | 0.1347 | 0.1347 | 0.1585 | 0.1585 | 0.1367 | 0.1367 | 0.1367 | 0.1367 | 0.1590 | 0.1590 | 0.1314 | 0.1314 | 0.1314 |
| 35 | 0.4167 | 0.4167 | 0.4167 | 0.4167 | 0.3972 | 0.3972 | 0.4316 | 0.4316 | 0.4316 | 0.4316 | 0.4129 | 0.4129 | 0.3967 | 0.3967 | 0.3967 |
| 36 | 0.1440 | 0.1440 | 0.1440 | 0.1440 | 0.1641 | 0.1641 | 0.1480 | 0.1480 | 0.1480 | 0.1480 | 0.1673 | 0.1673 | 0.1378 | 0.1378 | 0.1378 |
| 37 | 0.3815 | 0.3815 | 0.3815 | 0.3815 | 0.4366 | 0.4366 | 0.3909 | 0.3909 | 0.3909 | 0.3909 | 0.4438 | 0.4438 | 0.3632 | 0.3632 | 0.3632 |
| 38 | 0.2417 | 0.2417 | 0.2417 | 0.2417 | 0.2155 | 0.2155 | 0.2524 | 0.2524 | 0.2524 | 0.2524 | 0.2275 | 0.2275 | 0.2215 | 0.2215 | 0.2215 |
| 39 | 0.1367 | 0.1367 | 0.1367 | 0.1367 | 0.1367 | 0.1367 | 0.1406 | 0.1406 | 0.1406 | 0.1406 | 0.1406 | 0.1406 | 0.1291 | 0.1291 | 0.1291 |
| 40 | 0.2198 | 0.2198 | 0.2198 | 0.2198 | 0.2558 | 0.2558 | 0.2383 | 0.2383 | 0.2383 | 0.2383 | 0.2750 | 0.2750 | 0.1912 | 0.1912 | 0.1912 |
| 41 | 0.4225 | 0.4225 | 0.4225 | 0.4225 | 0.4004 | 0.4004 | 0.4342 | 0.4342 | 0.4342 | 0.4342 | 0.4124 | 0.4124 | 0.3837 | 0.3837 | 0.3837 |
| 42 | 0.1368 | 0.1368 | 0.1368 | 0.1368 | 0.1368 | 0.1368 | 0.1419 | 0.1419 | 0.1419 | 0.1419 | 0.1419 | 0.1419 | 0.1270 | 0.1270 | 0.1270 |
| 43 | 0.3592 | 0.3592 | 0.3592 | 0.3592 | 0.4235 | 0.4235 | 0.3566 | 0.3566 | 0.3566 | 0.3566 | 0.4201 | 0.4201 | 0.3322 | 0.3322 | 0.3322 |
| 44 | 0.1634 | 0.1634 | 0.1634 | 0.1634 | 0.1634 | 0.1634 | 0.1694 | 0.1694 | 0.1694 | 0.1694 | 0.1694 | 0.1694 | 0.1437 | 0.1437 | 0.1437 |
| 45 | 0.1124 | 0.1124 | 0.1124 | 0.1124 | 0.1124 | 0.1124 | 0.1150 | 0.1150 | 0.1150 | 0.1150 | 0.1150 | 0.1150 | 0.1080 | 0.1080 | 0.1080 |
| 46 | 0.2159 | 0.2159 | 0.2159 | 0.2159 | 0.2159 | 0.2159 | 0.2534 | 0.2534 | 0.2534 | 0.2534 | 0.2534 | 0.2534 | 0.1617 | 0.1617 | 0.1617 |
| 47 | 0.4163 | 0.4163 | 0.4163 | 0.4163 | 0.4600 | 0.4600 | 0.3576 | 0.3576 | 0.3576 | 0.3576 | 0.3957 | 0.3957 | 0.3820 | 0.3820 | 0.3820 |
| 48 | 0.1550 | 0.1550 | 0.1550 | 0.1550 | 0.1914 | 0.1914 | 0.1208 | 0.1208 | 0.1208 | 0.1208 | 0.1497 | 0.1497 | 0.1494 | 0.1494 | 0.1494 |
| 49 | 0.3388 | 0.3388 | 0.3388 | 0.3388 | 0.3773 | 0.3773 | 0.3082 | 0.3082 | 0.3082 | 0.3082 | 0.3368 | 0.3368 | 0.3440 | 0.3440 | 0.3440 |
| 50 | 0.4183 | 0.4183 | 0.4183 | 0.4183 | 0.4586 | 0.4586 | 0.3801 | 0.3801 | 0.3801 | 0.3801 | 0.4092 | 0.4092 | 0.2903 | 0.2903 | 0.2903 |

| **Harmonic Order** | **PQ16a** | **PQ17a** | **PQ18a** | **PQ19a** | **PQ20a** | **PQ21a** | **PQ22a** | **PQ23a** | **PQ24a** | **PQ25a** | **PQ26a** | **PQ27a** | **PQ28a** | **PQ29a** | **PQ30a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 2.1576 | 2.2169 | 2.2169 | 2.2081 | 2.2081 | 2.2081 | 2.2081 | 2.2701 | 2.2701 | 2.2277 | 2.2277 | 2.2277 | 2.2277 | 2.2945 | 2.2945 |
| 2 | 0.3950 | 0.3923 | 0.3923 | 0.3951 | 0.3951 | 0.3951 | 0.3951 | 0.3927 | 0.3927 | 0.3875 | 0.3875 | 0.3875 | 0.3875 | 0.3848 | 0.3848 |
| 3 | 0.1992 | 0.1979 | 0.1979 | 0.1993 | 0.1993 | 0.1993 | 0.1993 | 0.1981 | 0.1981 | 0.1963 | 0.1963 | 0.1963 | 0.1963 | 0.1950 | 0.1950 |
| 4 | 0.2590 | 0.2549 | 0.2549 | 0.2592 | 0.2592 | 0.2592 | 0.2592 | 0.2555 | 0.2555 | 0.2651 | 0.2651 | 0.2651 | 0.2651 | 0.2610 | 0.2610 |
| 5 | 0.7110 | 0.7078 | 0.7078 | 0.7117 | 0.7117 | 0.7117 | 0.7117 | 0.7088 | 0.7088 | 0.7112 | 0.7112 | 0.7112 | 0.7112 | 0.7081 | 0.7081 |
| 6 | 0.1049 | 0.1077 | 0.1077 | 0.1051 | 0.1051 | 0.1051 | 0.1051 | 0.1078 | 0.1078 | 0.1053 | 0.1053 | 0.1053 | 0.1053 | 0.1082 | 0.1082 |
| 7 | 0.4989 | 0.4989 | 0.4989 | 0.5037 | 0.5037 | 0.5037 | 0.5037 | 0.5037 | 0.5037 | 0.5128 | 0.5128 | 0.5128 | 0.5128 | 0.5128 | 0.5128 |
| 8 | 0.1696 | 0.1989 | 0.1989 | 0.1711 | 0.1711 | 0.1711 | 0.1711 | 0.1990 | 0.1990 | 0.1749 | 0.1749 | 0.1749 | 0.1749 | 0.2040 | 0.2040 |
| 9 | 0.1291 | 0.1291 | 0.1291 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1294 | 0.1300 | 0.1300 | 0.1300 | 0.1300 | 0.1300 | 0.1300 |
| 10 | 0.2542 | 0.2734 | 0.2734 | 0.2631 | 0.2631 | 0.2631 | 0.2631 | 0.2815 | 0.2815 | 0.2714 | 0.2714 | 0.2714 | 0.2714 | 0.2907 | 0.2907 |
| 11 | 0.5308 | 0.5436 | 0.5436 | 0.5539 | 0.5539 | 0.5539 | 0.5539 | 0.5664 | 0.5664 | 0.5710 | 0.5710 | 0.5710 | 0.5710 | 0.5841 | 0.5841 |
| 12 | 0.1125 | 0.1253 | 0.1253 | 0.1171 | 0.1171 | 0.1171 | 0.1171 | 0.1298 | 0.1298 | 0.1184 | 0.1184 | 0.1184 | 0.1184 | 0.1315 | 0.1315 |
| 13 | 0.5171 | 0.5319 | 0.5319 | 0.5565 | 0.5565 | 0.5565 | 0.5565 | 0.5716 | 0.5716 | 0.5606 | 0.5606 | 0.5606 | 0.5606 | 0.5759 | 0.5759 |
| 14 | 0.2303 | 0.2425 | 0.2425 | 0.2571 | 0.2571 | 0.2571 | 0.2571 | 0.2701 | 0.2701 | 0.2530 | 0.2530 | 0.2530 | 0.2530 | 0.2657 | 0.2657 |
| 15 | 0.2620 | 0.2483 | 0.2483 | 0.2889 | 0.2889 | 0.2889 | 0.2889 | 0.2731 | 0.2731 | 0.2804 | 0.2804 | 0.2804 | 0.2804 | 0.2659 | 0.2659 |
| 16 | 0.3467 | 0.3642 | 0.3642 | 0.4242 | 0.4242 | 0.4242 | 0.4242 | 0.4477 | 0.4477 | 0.3964 | 0.3964 | 0.3964 | 0.3964 | 0.4162 | 0.4162 |
| 17 | 0.6727 | 0.7240 | 0.7240 | 0.4880 | 0.4880 | 0.4880 | 0.4880 | 0.5065 | 0.5065 | 0.5810 | 0.5810 | 0.5810 | 0.5810 | 0.6235 | 0.6235 |
| 18 | 0.1185 | 0.1185 | 0.1185 | 0.1290 | 0.1290 | 0.1290 | 0.1290 | 0.1290 | 0.1290 | 0.1177 | 0.1177 | 0.1177 | 0.1177 | 0.1177 | 0.1177 |
| 19 | 0.4684 | 0.4732 | 0.4732 | 0.4956 | 0.4956 | 0.4956 | 0.4956 | 0.4992 | 0.4992 | 0.4616 | 0.4616 | 0.4616 | 0.4616 | 0.4663 | 0.4663 |
| 20 | 0.1657 | 0.1657 | 0.1657 | 0.1646 | 0.1646 | 0.1646 | 0.1646 | 0.1646 | 0.1646 | 0.1676 | 0.1676 | 0.1676 | 0.1676 | 0.1676 | 0.1676 |
| 21 | 0.1098 | 0.1098 | 0.1098 | 0.1085 | 0.1085 | 0.1085 | 0.1085 | 0.1085 | 0.1085 | 0.1111 | 0.1111 | 0.1111 | 0.1111 | 0.1111 | 0.1111 |
| 22 | 0.1255 | 0.1289 | 0.1289 | 0.1256 | 0.1256 | 0.1256 | 0.1256 | 0.1286 | 0.1286 | 0.1258 | 0.1258 | 0.1258 | 0.1258 | 0.1290 | 0.1290 |
| 23 | 0.4417 | 0.4417 | 0.4417 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4418 | 0.4418 | 0.4418 | 0.4418 | 0.4418 | 0.4418 |
| 24 | 0.1159 | 0.1159 | 0.1159 | 0.1165 | 0.1165 | 0.1165 | 0.1165 | 0.1165 | 0.1165 | 0.1153 | 0.1153 | 0.1153 | 0.1153 | 0.1153 | 0.1153 |
| 25 | 0.3910 | 0.3927 | 0.3927 | 0.3934 | 0.3934 | 0.3934 | 0.3934 | 0.3949 | 0.3949 | 0.3881 | 0.3881 | 0.3881 | 0.3881 | 0.3898 | 0.3898 |
| 26 | 0.1218 | 0.1246 | 0.1246 | 0.1225 | 0.1225 | 0.1225 | 0.1225 | 0.1250 | 0.1250 | 0.1217 | 0.1217 | 0.1217 | 0.1217 | 0.1246 | 0.1246 |
| 27 | 0.1173 | 0.1144 | 0.1144 | 0.1168 | 0.1168 | 0.1168 | 0.1168 | 0.1142 | 0.1142 | 0.1194 | 0.1194 | 0.1194 | 0.1194 | 0.1164 | 0.1164 |
| 28 | 0.2188 | 0.2381 | 0.2381 | 0.2179 | 0.2179 | 0.2179 | 0.2179 | 0.2353 | 0.2353 | 0.2301 | 0.2301 | 0.2301 | 0.2301 | 0.2497 | 0.2497 |
| 29 | 0.4770 | 0.4581 | 0.4581 | 0.4691 | 0.4691 | 0.4691 | 0.4691 | 0.4522 | 0.4522 | 0.4998 | 0.4998 | 0.4998 | 0.4998 | 0.4797 | 0.4797 |
| 30 | 0.1362 | 0.1330 | 0.1330 | 0.1355 | 0.1355 | 0.1355 | 0.1355 | 0.1326 | 0.1326 | 0.1406 | 0.1406 | 0.1406 | 0.1406 | 0.1373 | 0.1373 |
| 31 | 0.3556 | 0.3624 | 0.3624 | 0.3547 | 0.3547 | 0.3547 | 0.3547 | 0.3610 | 0.3610 | 0.3603 | 0.3603 | 0.3603 | 0.3603 | 0.3676 | 0.3676 |
| 32 | 0.1404 | 0.1422 | 0.1422 | 0.1418 | 0.1418 | 0.1418 | 0.1418 | 0.1435 | 0.1435 | 0.1457 | 0.1457 | 0.1457 | 0.1457 | 0.1476 | 0.1476 |
| 33 | 0.1061 | 0.1105 | 0.1105 | 0.1067 | 0.1067 | 0.1067 | 0.1067 | 0.1109 | 0.1109 | 0.1072 | 0.1072 | 0.1072 | 0.1072 | 0.1120 | 0.1120 |
| 34 | 0.1314 | 0.1544 | 0.1544 | 0.1340 | 0.1340 | 0.1340 | 0.1340 | 0.1566 | 0.1566 | 0.1355 | 0.1355 | 0.1355 | 0.1355 | 0.1607 | 0.1607 |
| 35 | 0.3967 | 0.3781 | 0.3781 | 0.4153 | 0.4153 | 0.4153 | 0.4153 | 0.3966 | 0.3966 | 0.4182 | 0.4182 | 0.4182 | 0.4182 | 0.3978 | 0.3978 |
| 36 | 0.1378 | 0.1567 | 0.1567 | 0.1436 | 0.1436 | 0.1436 | 0.1436 | 0.1629 | 0.1629 | 0.1443 | 0.1443 | 0.1443 | 0.1443 | 0.1653 | 0.1653 |
| 37 | 0.3632 | 0.4141 | 0.4141 | 0.3787 | 0.3787 | 0.3787 | 0.3787 | 0.4315 | 0.4315 | 0.3843 | 0.3843 | 0.3843 | 0.3843 | 0.4420 | 0.4420 |
| 38 | 0.2215 | 0.1963 | 0.1963 | 0.2364 | 0.2364 | 0.2364 | 0.2364 | 0.2117 | 0.2117 | 0.2502 | 0.2502 | 0.2502 | 0.2502 | 0.2212 | 0.2212 |
| 39 | 0.1291 | 0.1291 | 0.1291 | 0.1358 | 0.1358 | 0.1358 | 0.1358 | 0.1358 | 0.1358 | 0.1377 | 0.1377 | 0.1377 | 0.1377 | 0.1377 | 0.1377 |
| 40 | 0.1912 | 0.2213 | 0.2213 | 0.2171 | 0.2171 | 0.2171 | 0.2171 | 0.2520 | 0.2520 | 0.2227 | 0.2227 | 0.2227 | 0.2227 | 0.2598 | 0.2598 |
| 41 | 0.3837 | 0.3651 | 0.3651 | 0.4181 | 0.4181 | 0.4181 | 0.4181 | 0.3965 | 0.3965 | 0.4272 | 0.4272 | 0.4272 | 0.4272 | 0.4045 | 0.4045 |
| 42 | 0.1270 | 0.1270 | 0.1270 | 0.1364 | 0.1364 | 0.1364 | 0.1364 | 0.1364 | 0.1364 | 0.1373 | 0.1373 | 0.1373 | 0.1373 | 0.1373 | 0.1373 |
| 43 | 0.3322 | 0.3831 | 0.3831 | 0.3585 | 0.3585 | 0.3585 | 0.3585 | 0.4223 | 0.4223 | 0.3600 | 0.3600 | 0.3600 | 0.3600 | 0.4247 | 0.4247 |
| 44 | 0.1437 | 0.1437 | 0.1437 | 0.1640 | 0.1640 | 0.1640 | 0.1640 | 0.1640 | 0.1640 | 0.1628 | 0.1628 | 0.1628 | 0.1628 | 0.1628 | 0.1628 |
| 45 | 0.1080 | 0.1080 | 0.1080 | 0.1126 | 0.1126 | 0.1126 | 0.1126 | 0.1126 | 0.1126 | 0.1121 | 0.1121 | 0.1121 | 0.1121 | 0.1121 | 0.1121 |
| 46 | 0.1617 | 0.1617 | 0.1617 | 0.2211 | 0.2211 | 0.2211 | 0.2211 | 0.2211 | 0.2211 | 0.2109 | 0.2109 | 0.2109 | 0.2109 | 0.2109 | 0.2109 |
| 47 | 0.3820 | 0.4135 | 0.4135 | 0.4211 | 0.4211 | 0.4211 | 0.4211 | 0.4669 | 0.4669 | 0.4107 | 0.4107 | 0.4107 | 0.4107 | 0.4524 | 0.4524 |
| 48 | 0.1494 | 0.1721 | 0.1721 | 0.1494 | 0.1494 | 0.1494 | 0.1494 | 0.1871 | 0.1871 | 0.1591 | 0.1591 | 0.1591 | 0.1591 | 0.1938 | 0.1938 |
| 49 | 0.3440 | 0.3722 | 0.3722 | 0.3423 | 0.3423 | 0.3423 | 0.3423 | 0.3805 | 0.3805 | 0.3382 | 0.3382 | 0.3382 | 0.3382 | 0.3756 | 0.3756 |
| 50 | 0.2903 | 0.3143 | 0.3143 | 0.4151 | 0.4151 | 0.4151 | 0.4151 | 0.4530 | 0.4530 | 0.3724 | 0.3724 | 0.3724 | 0.3724 | 0.4094 | 0.4094 |

| **Harmonic Order** | **PQ31a** | **PQ32a** | **PQ33a** | **PQ34a** | **PQ35a** | **PQ36a** | **PQ37a** | **PQ38a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 2.2985 | 2.2985 | 1.9419 | 1.9419 | 1.9808 | 1.9808 | 2.0296 | 2.0296 |
| 2 | 0.4272 | 0.4272 | 0.4196 | 0.4196 | 0.4161 | 0.4161 | 0.3932 | 0.3932 |
| 3 | 0.2130 | 0.2130 | 0.2086 | 0.2086 | 0.2069 | 0.2069 | 0.2032 | 0.2032 |
| 4 | 0.2385 | 0.2385 | 0.2396 | 0.2396 | 0.2349 | 0.2349 | 0.2661 | 0.2661 |
| 5 | 0.7188 | 0.7188 | 0.7082 | 0.7082 | 0.7043 | 0.7043 | 0.7021 | 0.7021 |
| 6 | 0.1057 | 0.1057 | 0.1028 | 0.1028 | 0.1064 | 0.1064 | 0.1196 | 0.1196 |
| 7 | 0.4783 | 0.4783 | 0.4439 | 0.4439 | 0.4439 | 0.4439 | 0.4224 | 0.4224 |
| 8 | 0.1605 | 0.1605 | 0.1509 | 0.1509 | 0.1863 | 0.1863 | 0.1833 | 0.1833 |
| 9 | 0.1277 | 0.1277 | 0.1256 | 0.1256 | 0.1256 | 0.1256 | 0.1400 | 0.1400 |
| 10 | 0.2273 | 0.2273 | 0.1888 | 0.1888 | 0.2109 | 0.2109 | 0.2573 | 0.2573 |
| 11 | 0.4689 | 0.4689 | 0.3804 | 0.3804 | 0.3941 | 0.3941 | 0.4823 | 0.4823 |
| 12 | 0.1077 | 0.1077 | 0.0935 | 0.0935 | 0.1047 | 0.1047 | 0.1448 | 0.1448 |
| 13 | 0.4262 | 0.4262 | 0.3522 | 0.3522 | 0.3662 | 0.3662 | 0.4788 | 0.4788 |
| 14 | 0.1810 | 0.1810 | 0.1424 | 0.1424 | 0.1528 | 0.1528 | 0.2144 | 0.2144 |
| 15 | 0.2334 | 0.2334 | 0.1921 | 0.1921 | 0.1822 | 0.1822 | 0.2686 | 0.2686 |
| 16 | 0.2805 | 0.2805 | 0.2010 | 0.2010 | 0.2117 | 0.2117 | 0.3908 | 0.3908 |
| 17 | 1.1032 | 1.1032 | 0.7797 | 0.7797 | 0.8109 | 0.8109 | 0.5171 | 0.5171 |
| 18 | 0.1112 | 0.1112 | 0.2102 | 0.2102 | 0.2102 | 0.2102 | 0.1314 | 0.1314 |
| 19 | 0.3799 | 0.3799 | 0.4413 | 0.4413 | 0.4529 | 0.4529 | 0.4861 | 0.4861 |
| 20 | 0.1593 | 0.1593 | 0.1462 | 0.1462 | 0.1462 | 0.1462 | 0.1616 | 0.1616 |
| 21 | 0.1104 | 0.1104 | 0.1096 | 0.1096 | 0.1096 | 0.1096 | 0.1161 | 0.1161 |
| 22 | 0.1233 | 0.1233 | 0.1221 | 0.1221 | 0.1287 | 0.1287 | 0.1258 | 0.1258 |
| 23 | 0.4386 | 0.4386 | 0.4383 | 0.4383 | 0.4383 | 0.4383 | 0.4415 | 0.4415 |
| 24 | 0.1157 | 0.1157 | 0.1155 | 0.1155 | 0.1155 | 0.1155 | 0.1173 | 0.1173 |
| 25 | 0.3926 | 0.3926 | 0.3909 | 0.3909 | 0.3934 | 0.3934 | 0.3930 | 0.3930 |
| 26 | 0.1244 | 0.1244 | 0.1200 | 0.1200 | 0.1240 | 0.1240 | 0.1196 | 0.1196 |
| 27 | 0.1163 | 0.1163 | 0.1130 | 0.1130 | 0.1091 | 0.1091 | 0.1292 | 0.1292 |
| 28 | 0.2215 | 0.2215 | 0.1902 | 0.1902 | 0.2157 | 0.2157 | 0.2242 | 0.2242 |
| 29 | 0.4471 | 0.4471 | 0.4422 | 0.4422 | 0.4207 | 0.4207 | 0.4475 | 0.4475 |
| 30 | 0.1351 | 0.1351 | 0.1277 | 0.1277 | 0.1239 | 0.1239 | 0.1348 | 0.1348 |
| 31 | 0.3503 | 0.3503 | 0.3473 | 0.3473 | 0.3552 | 0.3552 | 0.3518 | 0.3518 |
| 32 | 0.1565 | 0.1565 | 0.1278 | 0.1278 | 0.1298 | 0.1298 | 0.1270 | 0.1270 |
| 33 | 0.1121 | 0.1121 | 0.1030 | 0.1030 | 0.1077 | 0.1077 | 0.1093 | 0.1093 |
| 34 | 0.1639 | 0.1639 | 0.1208 | 0.1208 | 0.1446 | 0.1446 | 0.1312 | 0.1312 |
| 35 | 0.7071 | 0.7071 | 0.3399 | 0.3399 | 0.3215 | 0.3215 | 0.3559 | 0.3559 |
| 36 | 0.1474 | 0.1474 | 0.1209 | 0.1209 | 0.1387 | 0.1387 | 0.1858 | 0.1858 |
| 37 | 0.3813 | 0.3813 | 0.3140 | 0.3140 | 0.3597 | 0.3597 | 0.3815 | 0.3815 |
| 38 | 0.3594 | 0.3594 | 0.1615 | 0.1615 | 0.1394 | 0.1394 | 0.1738 | 0.1738 |
| 39 | 0.1881 | 0.1881 | 0.1111 | 0.1111 | 0.1111 | 0.1111 | 0.1747 | 0.1747 |
| 40 | 0.2184 | 0.2184 | 0.1351 | 0.1351 | 0.1570 | 0.1570 | 0.2388 | 0.2388 |
| 41 | 0.3060 | 0.3060 | 0.2980 | 0.2980 | 0.2847 | 0.2847 | 0.3288 | 0.3288 |
| 42 | 0.1121 | 0.1121 | 0.1092 | 0.1092 | 0.1092 | 0.1092 | 0.1197 | 0.1197 |
| 43 | 0.2846 | 0.2846 | 0.2694 | 0.2694 | 0.3005 | 0.3005 | 0.2911 | 0.2911 |
| 44 | 0.2380 | 0.2380 | 0.1116 | 0.1116 | 0.1116 | 0.1116 | 0.1218 | 0.1218 |
| 45 | 0.1212 | 0.1212 | 0.1022 | 0.1022 | 0.1022 | 0.1022 | 0.1069 | 0.1069 |
| 46 | 0.1179 | 0.1179 | 0.1154 | 0.1154 | 0.1154 | 0.1154 | 0.1630 | 0.1630 |
| 47 | 0.2429 | 0.2429 | 0.2590 | 0.2590 | 0.2724 | 0.2724 | 0.2813 | 0.2813 |
| 48 | 0.1060 | 0.1060 | 0.1110 | 0.1110 | 0.1186 | 0.1186 | 0.1155 | 0.1155 |
| 49 | 0.2312 | 0.2312 | 0.2345 | 0.2345 | 0.2436 | 0.2436 | 0.2241 | 0.2241 |
| 50 | 0.1560 | 0.1560 | 0.1256 | 0.1256 | 0.1309 | 0.1309 | 0.2421 | 0.2421 |

### With harmonic filters in service

| **Harmonic Order** | **PQ01b** | **PQ02b** | **PQ03b** | **PQ04b** | **PQ05b** | **PQ06b** | **PQ07b** | **PQ08b** | **PQ09b** | **PQ10b** | **PQ11b** | **PQ12b** | **PQ13b** | **PQ14b** | **PQ15b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 1.8164 | 1.8164 | 1.8164 | 1.8164 | 1.8271 | 1.8271 | 1.8066 | 1.8066 | 1.8066 | 1.8066 | 1.8134 | 1.8134 | 1.8007 | 1.8007 | 1.8007 |
| 2 | 0.3950 | 0.3950 | 0.3950 | 0.3950 | 0.3923 | 0.3923 | 0.3999 | 0.3999 | 0.3999 | 0.3999 | 0.3976 | 0.3976 | 0.3988 | 0.3988 | 0.3988 |
| 3 | 0.2027 | 0.2027 | 0.2027 | 0.2027 | 0.2013 | 0.2013 | 0.2052 | 0.2052 | 0.2052 | 0.2052 | 0.2039 | 0.2039 | 0.2045 | 0.2045 | 0.2045 |
| 4 | 0.2595 | 0.2595 | 0.2595 | 0.2595 | 0.2551 | 0.2551 | 0.2555 | 0.2555 | 0.2555 | 0.2555 | 0.2517 | 0.2517 | 0.2558 | 0.2558 | 0.2558 |
| 5 | 0.7530 | 0.7530 | 0.7530 | 0.7530 | 0.7489 | 0.7489 | 0.7696 | 0.7696 | 0.7696 | 0.7696 | 0.7622 | 0.7622 | 0.7610 | 0.7610 | 0.7610 |
| 6 | 0.1245 | 0.1245 | 0.1245 | 0.1245 | 0.1319 | 0.1319 | 0.1252 | 0.1252 | 0.1252 | 0.1252 | 0.1311 | 0.1311 | 0.1238 | 0.1238 | 0.1238 |
| 7 | 0.4248 | 0.4248 | 0.4248 | 0.4248 | 0.4248 | 0.4248 | 0.4024 | 0.4024 | 0.4024 | 0.4024 | 0.4024 | 0.4024 | 0.4037 | 0.4037 | 0.4037 |
| 8 | 0.1403 | 0.1403 | 0.1403 | 0.1403 | 0.1591 | 0.1591 | 0.1366 | 0.1366 | 0.1366 | 0.1366 | 0.1524 | 0.1524 | 0.1366 | 0.1366 | 0.1366 |
| 9 | 0.1185 | 0.1185 | 0.1185 | 0.1185 | 0.1185 | 0.1185 | 0.1177 | 0.1177 | 0.1177 | 0.1177 | 0.1177 | 0.1177 | 0.1179 | 0.1179 | 0.1179 |
| 10 | 0.1689 | 0.1689 | 0.1689 | 0.1689 | 0.1801 | 0.1801 | 0.1612 | 0.1612 | 0.1612 | 0.1612 | 0.1705 | 0.1705 | 0.1599 | 0.1599 | 0.1599 |
| 11 | 0.3481 | 0.3481 | 0.3481 | 0.3481 | 0.3555 | 0.3555 | 0.3307 | 0.3307 | 0.3307 | 0.3307 | 0.3369 | 0.3369 | 0.3291 | 0.3291 | 0.3291 |
| 12 | 0.0887 | 0.0887 | 0.0887 | 0.0887 | 0.0932 | 0.0932 | 0.0872 | 0.0872 | 0.0872 | 0.0872 | 0.0904 | 0.0904 | 0.0873 | 0.0873 | 0.0873 |
| 13 | 0.3400 | 0.3400 | 0.3400 | 0.3400 | 0.3486 | 0.3486 | 0.3223 | 0.3223 | 0.3223 | 0.3223 | 0.3295 | 0.3295 | 0.3223 | 0.3223 | 0.3223 |
| 14 | 0.1598 | 0.1598 | 0.1598 | 0.1598 | 0.1674 | 0.1674 | 0.1508 | 0.1508 | 0.1508 | 0.1508 | 0.1572 | 0.1572 | 0.1505 | 0.1505 | 0.1505 |
| 15 | 0.1590 | 0.1590 | 0.1590 | 0.1590 | 0.1543 | 0.1543 | 0.1559 | 0.1559 | 0.1559 | 0.1559 | 0.1524 | 0.1524 | 0.1577 | 0.1577 | 0.1577 |
| 16 | 0.1578 | 0.1578 | 0.1578 | 0.1578 | 0.1629 | 0.1629 | 0.1536 | 0.1536 | 0.1536 | 0.1536 | 0.1579 | 0.1579 | 0.1539 | 0.1539 | 0.1539 |
| 17 | 0.5117 | 0.5117 | 0.5117 | 0.5117 | 0.5162 | 0.5162 | 0.5095 | 0.5095 | 0.5095 | 0.5095 | 0.5134 | 0.5134 | 0.5094 | 0.5094 | 0.5094 |
| 18 | 0.1264 | 0.1264 | 0.1264 | 0.1264 | 0.1264 | 0.1264 | 0.1255 | 0.1255 | 0.1255 | 0.1255 | 0.1255 | 0.1255 | 0.1253 | 0.1253 | 0.1253 |
| 19 | 0.4992 | 0.4992 | 0.4992 | 0.4992 | 0.5010 | 0.5010 | 0.4970 | 0.4970 | 0.4970 | 0.4970 | 0.4986 | 0.4986 | 0.4961 | 0.4961 | 0.4961 |
| 20 | 0.1521 | 0.1521 | 0.1521 | 0.1521 | 0.1521 | 0.1521 | 0.1515 | 0.1515 | 0.1515 | 0.1515 | 0.1515 | 0.1515 | 0.1517 | 0.1517 | 0.1517 |
| 21 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1082 |
| 22 | 0.1244 | 0.1244 | 0.1244 | 0.1244 | 0.1264 | 0.1264 | 0.1242 | 0.1242 | 0.1242 | 0.1242 | 0.1259 | 0.1259 | 0.1242 | 0.1242 | 0.1242 |
| 23 | 0.4425 | 0.4425 | 0.4425 | 0.4425 | 0.4425 | 0.4425 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 | 0.4422 |
| 24 | 0.1157 | 0.1157 | 0.1157 | 0.1157 | 0.1157 | 0.1157 | 0.1156 | 0.1156 | 0.1156 | 0.1156 | 0.1156 | 0.1156 | 0.1156 | 0.1156 | 0.1156 |
| 25 | 0.3872 | 0.3872 | 0.3872 | 0.3872 | 0.3895 | 0.3895 | 0.3860 | 0.3860 | 0.3860 | 0.3860 | 0.3880 | 0.3880 | 0.3864 | 0.3864 | 0.3864 |
| 26 | 0.1186 | 0.1186 | 0.1186 | 0.1186 | 0.1217 | 0.1217 | 0.1169 | 0.1169 | 0.1169 | 0.1169 | 0.1194 | 0.1194 | 0.1173 | 0.1173 | 0.1173 |
| 27 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1088 | 0.1088 | 0.1093 | 0.1093 | 0.1093 | 0.1093 | 0.1084 | 0.1084 | 0.1094 | 0.1094 | 0.1094 |
| 28 | 0.1727 | 0.1727 | 0.1727 | 0.1727 | 0.1743 | 0.1743 | 0.1717 | 0.1717 | 0.1717 | 0.1717 | 0.1731 | 0.1731 | 0.1718 | 0.1718 | 0.1718 |
| 29 | 0.4401 | 0.4401 | 0.4401 | 0.4401 | 0.4391 | 0.4391 | 0.4397 | 0.4397 | 0.4397 | 0.4397 | 0.4389 | 0.4389 | 0.4397 | 0.4397 | 0.4397 |
| 30 | 0.1213 | 0.1213 | 0.1213 | 0.1213 | 0.1211 | 0.1211 | 0.1212 | 0.1212 | 0.1212 | 0.1212 | 0.1210 | 0.1210 | 0.1212 | 0.1212 | 0.1212 |
| 31 | 0.3465 | 0.3465 | 0.3465 | 0.3465 | 0.3473 | 0.3473 | 0.3462 | 0.3462 | 0.3462 | 0.3462 | 0.3470 | 0.3470 | 0.3462 | 0.3462 | 0.3462 |
| 32 | 0.1139 | 0.1139 | 0.1139 | 0.1139 | 0.1140 | 0.1140 | 0.1137 | 0.1137 | 0.1137 | 0.1137 | 0.1138 | 0.1138 | 0.1136 | 0.1136 | 0.1136 |
| 33 | 0.0997 | 0.0997 | 0.0997 | 0.0997 | 0.1001 | 0.1001 | 0.0997 | 0.0997 | 0.0997 | 0.0997 | 0.1000 | 0.1000 | 0.0997 | 0.0997 | 0.0997 |
| 34 | 0.1099 | 0.1099 | 0.1099 | 0.1099 | 0.1128 | 0.1128 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1117 | 0.1117 | 0.1098 | 0.1098 | 0.1098 |
| 35 | 0.2878 | 0.2878 | 0.2878 | 0.2878 | 0.2871 | 0.2871 | 0.2875 | 0.2875 | 0.2875 | 0.2875 | 0.2870 | 0.2870 | 0.2873 | 0.2873 | 0.2873 |
| 36 | 0.1167 | 0.1167 | 0.1167 | 0.1167 | 0.1176 | 0.1176 | 0.1166 | 0.1166 | 0.1166 | 0.1166 | 0.1173 | 0.1173 | 0.1166 | 0.1166 | 0.1166 |
| 37 | 0.2771 | 0.2771 | 0.2771 | 0.2771 | 0.2864 | 0.2864 | 0.2770 | 0.2770 | 0.2770 | 0.2770 | 0.2835 | 0.2835 | 0.2768 | 0.2768 | 0.2768 |
| 38 | 0.1489 | 0.1489 | 0.1489 | 0.1489 | 0.1426 | 0.1426 | 0.1469 | 0.1469 | 0.1469 | 0.1469 | 0.1415 | 0.1415 | 0.1456 | 0.1456 | 0.1456 |
| 39 | 0.1105 | 0.1105 | 0.1105 | 0.1105 | 0.1105 | 0.1105 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 |
| 40 | 0.1127 | 0.1127 | 0.1127 | 0.1127 | 0.1184 | 0.1184 | 0.1119 | 0.1119 | 0.1119 | 0.1119 | 0.1166 | 0.1166 | 0.1113 | 0.1113 | 0.1113 |
| 41 | 0.2678 | 0.2678 | 0.2678 | 0.2678 | 0.2635 | 0.2635 | 0.2659 | 0.2659 | 0.2659 | 0.2659 | 0.2622 | 0.2622 | 0.2636 | 0.2636 | 0.2636 |
| 42 | 0.1018 | 0.1018 | 0.1018 | 0.1018 | 0.1018 | 0.1018 | 0.1014 | 0.1014 | 0.1014 | 0.1014 | 0.1014 | 0.1014 | 0.1012 | 0.1012 | 0.1012 |
| 43 | 0.2449 | 0.2449 | 0.2449 | 0.2449 | 0.2557 | 0.2557 | 0.2434 | 0.2434 | 0.2434 | 0.2434 | 0.2527 | 0.2527 | 0.2427 | 0.2427 | 0.2427 |
| 44 | 0.1126 | 0.1126 | 0.1126 | 0.1126 | 0.1126 | 0.1126 | 0.1118 | 0.1118 | 0.1118 | 0.1118 | 0.1118 | 0.1118 | 0.1108 | 0.1108 | 0.1108 |
| 45 | 0.1011 | 0.1011 | 0.1011 | 0.1011 | 0.1011 | 0.1011 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 |
| 46 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1085 | 0.1085 | 0.1085 |
| 47 | 0.2423 | 0.2423 | 0.2423 | 0.2423 | 0.2479 | 0.2479 | 0.2405 | 0.2405 | 0.2405 | 0.2405 | 0.2453 | 0.2453 | 0.2374 | 0.2374 | 0.2374 |
| 48 | 0.1056 | 0.1056 | 0.1056 | 0.1056 | 0.1089 | 0.1089 | 0.1053 | 0.1053 | 0.1053 | 0.1053 | 0.1081 | 0.1081 | 0.1045 | 0.1045 | 0.1045 |
| 49 | 0.2266 | 0.2266 | 0.2266 | 0.2266 | 0.2308 | 0.2308 | 0.2251 | 0.2251 | 0.2251 | 0.2251 | 0.2287 | 0.2287 | 0.2227 | 0.2227 | 0.2227 |
| 50 | 0.1217 | 0.1217 | 0.1217 | 0.1217 | 0.1242 | 0.1242 | 0.1208 | 0.1208 | 0.1208 | 0.1208 | 0.1230 | 0.1230 | 0.1178 | 0.1178 | 0.1178 |

| **Harmonic Order** | **PQ16b** | **PQ17b** | **PQ18b** | **PQ19b** | **PQ20b** | **PQ21b** | **PQ22b** | **PQ23b** | **PQ24b** | **PQ25b** | **PQ26b** | **PQ27b** | **PQ28b** | **PQ29b** | **PQ30b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 1.8007 | 1.8087 | 1.8087 | 1.8158 | 1.8158 | 1.8158 | 1.8158 | 1.8263 | 1.8263 | 1.8181 | 1.8181 | 1.8181 | 1.8181 | 1.8290 | 1.8290 |
| 2 | 0.3988 | 0.3960 | 0.3960 | 0.3985 | 0.3985 | 0.3985 | 0.3985 | 0.3959 | 0.3959 | 0.3912 | 0.3912 | 0.3912 | 0.3912 | 0.3885 | 0.3885 |
| 3 | 0.2045 | 0.2030 | 0.2030 | 0.2040 | 0.2040 | 0.2040 | 0.2040 | 0.2026 | 0.2026 | 0.2014 | 0.2014 | 0.2014 | 0.2014 | 0.2000 | 0.2000 |
| 4 | 0.2558 | 0.2513 | 0.2513 | 0.2573 | 0.2573 | 0.2573 | 0.2573 | 0.2531 | 0.2531 | 0.2619 | 0.2619 | 0.2619 | 0.2619 | 0.2573 | 0.2573 |
| 5 | 0.7610 | 0.7522 | 0.7522 | 0.7523 | 0.7523 | 0.7523 | 0.7523 | 0.7483 | 0.7483 | 0.7538 | 0.7538 | 0.7538 | 0.7538 | 0.7496 | 0.7496 |
| 6 | 0.1238 | 0.1313 | 0.1313 | 0.1240 | 0.1240 | 0.1240 | 0.1240 | 0.1314 | 0.1314 | 0.1249 | 0.1249 | 0.1249 | 0.1249 | 0.1324 | 0.1324 |
| 7 | 0.4037 | 0.4037 | 0.4037 | 0.4238 | 0.4238 | 0.4238 | 0.4238 | 0.4238 | 0.4238 | 0.4261 | 0.4261 | 0.4261 | 0.4261 | 0.4261 | 0.4261 |
| 8 | 0.1366 | 0.1557 | 0.1557 | 0.1403 | 0.1403 | 0.1403 | 0.1403 | 0.1584 | 0.1584 | 0.1402 | 0.1402 | 0.1402 | 0.1402 | 0.1598 | 0.1598 |
| 9 | 0.1179 | 0.1179 | 0.1179 | 0.1190 | 0.1190 | 0.1190 | 0.1190 | 0.1190 | 0.1190 | 0.1179 | 0.1179 | 0.1179 | 0.1179 | 0.1179 | 0.1179 |
| 10 | 0.1599 | 0.1711 | 0.1711 | 0.1672 | 0.1672 | 0.1672 | 0.1672 | 0.1781 | 0.1781 | 0.1707 | 0.1707 | 0.1707 | 0.1707 | 0.1822 | 0.1822 |
| 11 | 0.3291 | 0.3365 | 0.3365 | 0.3461 | 0.3461 | 0.3461 | 0.3461 | 0.3533 | 0.3533 | 0.3499 | 0.3499 | 0.3499 | 0.3499 | 0.3574 | 0.3574 |
| 12 | 0.0873 | 0.0912 | 0.0912 | 0.0884 | 0.0884 | 0.0884 | 0.0884 | 0.0935 | 0.0935 | 0.0888 | 0.0888 | 0.0888 | 0.0888 | 0.0928 | 0.0928 |
| 13 | 0.3223 | 0.3309 | 0.3309 | 0.3389 | 0.3389 | 0.3389 | 0.3389 | 0.3474 | 0.3474 | 0.3409 | 0.3409 | 0.3409 | 0.3409 | 0.3497 | 0.3497 |
| 14 | 0.1505 | 0.1581 | 0.1581 | 0.1593 | 0.1593 | 0.1593 | 0.1593 | 0.1669 | 0.1669 | 0.1600 | 0.1600 | 0.1600 | 0.1600 | 0.1677 | 0.1677 |
| 15 | 0.1577 | 0.1533 | 0.1533 | 0.1572 | 0.1572 | 0.1572 | 0.1572 | 0.1528 | 0.1528 | 0.1617 | 0.1617 | 0.1617 | 0.1617 | 0.1565 | 0.1565 |
| 16 | 0.1539 | 0.1592 | 0.1592 | 0.1596 | 0.1596 | 0.1596 | 0.1596 | 0.1643 | 0.1643 | 0.1553 | 0.1553 | 0.1553 | 0.1553 | 0.1608 | 0.1608 |
| 17 | 0.5094 | 0.5143 | 0.5143 | 0.5230 | 0.5230 | 0.5230 | 0.5230 | 0.5271 | 0.5271 | 0.4977 | 0.4977 | 0.4977 | 0.4977 | 0.5029 | 0.5029 |
| 18 | 0.1253 | 0.1253 | 0.1253 | 0.1278 | 0.1278 | 0.1278 | 0.1278 | 0.1278 | 0.1278 | 0.1243 | 0.1243 | 0.1243 | 0.1243 | 0.1243 | 0.1243 |
| 19 | 0.4961 | 0.4981 | 0.4981 | 0.5066 | 0.5066 | 0.5066 | 0.5066 | 0.5082 | 0.5082 | 0.4891 | 0.4891 | 0.4891 | 0.4891 | 0.4911 | 0.4911 |
| 20 | 0.1517 | 0.1517 | 0.1517 | 0.1506 | 0.1506 | 0.1506 | 0.1506 | 0.1506 | 0.1506 | 0.1545 | 0.1545 | 0.1545 | 0.1545 | 0.1545 | 0.1545 |
| 21 | 0.1082 | 0.1082 | 0.1082 | 0.1073 | 0.1073 | 0.1073 | 0.1073 | 0.1073 | 0.1073 | 0.1095 | 0.1095 | 0.1095 | 0.1095 | 0.1095 | 0.1095 |
| 22 | 0.1242 | 0.1263 | 0.1263 | 0.1243 | 0.1243 | 0.1243 | 0.1243 | 0.1261 | 0.1261 | 0.1245 | 0.1245 | 0.1245 | 0.1245 | 0.1266 | 0.1266 |
| 23 | 0.4422 | 0.4422 | 0.4422 | 0.4424 | 0.4424 | 0.4424 | 0.4424 | 0.4424 | 0.4424 | 0.4423 | 0.4423 | 0.4423 | 0.4423 | 0.4423 | 0.4423 |
| 24 | 0.1156 | 0.1156 | 0.1156 | 0.1163 | 0.1163 | 0.1163 | 0.1163 | 0.1163 | 0.1163 | 0.1150 | 0.1150 | 0.1150 | 0.1150 | 0.1150 | 0.1150 |
| 25 | 0.3864 | 0.3887 | 0.3887 | 0.3903 | 0.3903 | 0.3903 | 0.3903 | 0.3924 | 0.3924 | 0.3834 | 0.3834 | 0.3834 | 0.3834 | 0.3858 | 0.3858 |
| 26 | 0.1173 | 0.1204 | 0.1204 | 0.1196 | 0.1196 | 0.1196 | 0.1196 | 0.1224 | 0.1224 | 0.1173 | 0.1173 | 0.1173 | 0.1173 | 0.1207 | 0.1207 |
| 27 | 0.1094 | 0.1083 | 0.1083 | 0.1093 | 0.1093 | 0.1093 | 0.1093 | 0.1083 | 0.1083 | 0.1105 | 0.1105 | 0.1105 | 0.1105 | 0.1092 | 0.1092 |
| 28 | 0.1718 | 0.1735 | 0.1735 | 0.1613 | 0.1613 | 0.1613 | 0.1613 | 0.1628 | 0.1628 | 0.1883 | 0.1883 | 0.1883 | 0.1883 | 0.1903 | 0.1903 |
| 29 | 0.4397 | 0.4387 | 0.4387 | 0.4250 | 0.4250 | 0.4250 | 0.4250 | 0.4242 | 0.4242 | 0.4596 | 0.4596 | 0.4596 | 0.4596 | 0.4584 | 0.4584 |
| 30 | 0.1212 | 0.1210 | 0.1210 | 0.1196 | 0.1196 | 0.1196 | 0.1196 | 0.1194 | 0.1194 | 0.1235 | 0.1235 | 0.1235 | 0.1235 | 0.1233 | 0.1233 |
| 31 | 0.3462 | 0.3471 | 0.3471 | 0.3440 | 0.3440 | 0.3440 | 0.3440 | 0.3447 | 0.3447 | 0.3495 | 0.3495 | 0.3495 | 0.3495 | 0.3505 | 0.3505 |
| 32 | 0.1136 | 0.1138 | 0.1138 | 0.1134 | 0.1134 | 0.1134 | 0.1134 | 0.1136 | 0.1136 | 0.1144 | 0.1144 | 0.1144 | 0.1144 | 0.1146 | 0.1146 |
| 33 | 0.0997 | 0.1001 | 0.1001 | 0.0998 | 0.0998 | 0.0998 | 0.0998 | 0.1002 | 0.1002 | 0.0997 | 0.0997 | 0.0997 | 0.0997 | 0.1001 | 0.1001 |
| 34 | 0.1098 | 0.1122 | 0.1122 | 0.1101 | 0.1101 | 0.1101 | 0.1101 | 0.1135 | 0.1135 | 0.1098 | 0.1098 | 0.1098 | 0.1098 | 0.1121 | 0.1121 |
| 35 | 0.2873 | 0.2867 | 0.2867 | 0.2888 | 0.2888 | 0.2888 | 0.2888 | 0.2880 | 0.2880 | 0.2867 | 0.2867 | 0.2867 | 0.2867 | 0.2860 | 0.2860 |
| 36 | 0.1166 | 0.1175 | 0.1175 | 0.1153 | 0.1153 | 0.1153 | 0.1153 | 0.1161 | 0.1161 | 0.1184 | 0.1184 | 0.1184 | 0.1184 | 0.1195 | 0.1195 |
| 37 | 0.2768 | 0.2839 | 0.2839 | 0.2780 | 0.2780 | 0.2780 | 0.2780 | 0.2883 | 0.2883 | 0.2759 | 0.2759 | 0.2759 | 0.2759 | 0.2835 | 0.2835 |
| 38 | 0.1456 | 0.1397 | 0.1397 | 0.1433 | 0.1433 | 0.1433 | 0.1433 | 0.1373 | 0.1373 | 0.1562 | 0.1562 | 0.1562 | 0.1562 | 0.1495 | 0.1495 |
| 39 | 0.1101 | 0.1101 | 0.1101 | 0.1078 | 0.1078 | 0.1078 | 0.1078 | 0.1078 | 0.1078 | 0.1140 | 0.1140 | 0.1140 | 0.1140 | 0.1140 | 0.1140 |
| 40 | 0.1113 | 0.1158 | 0.1158 | 0.1131 | 0.1131 | 0.1131 | 0.1131 | 0.1192 | 0.1192 | 0.1150 | 0.1150 | 0.1150 | 0.1150 | 0.1196 | 0.1196 |
| 41 | 0.2636 | 0.2595 | 0.2595 | 0.2677 | 0.2677 | 0.2677 | 0.2677 | 0.2637 | 0.2637 | 0.2675 | 0.2675 | 0.2675 | 0.2675 | 0.2636 | 0.2636 |
| 42 | 0.1012 | 0.1012 | 0.1012 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 |
| 43 | 0.2427 | 0.2528 | 0.2528 | 0.2461 | 0.2461 | 0.2461 | 0.2461 | 0.2564 | 0.2564 | 0.2462 | 0.2462 | 0.2462 | 0.2462 | 0.2579 | 0.2579 |
| 44 | 0.1108 | 0.1108 | 0.1108 | 0.1103 | 0.1103 | 0.1103 | 0.1103 | 0.1103 | 0.1103 | 0.1154 | 0.1154 | 0.1154 | 0.1154 | 0.1154 | 0.1154 |
| 45 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1009 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 | 0.1020 |
| 46 | 0.1085 | 0.1085 | 0.1085 | 0.1102 | 0.1102 | 0.1102 | 0.1102 | 0.1102 | 0.1102 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 | 0.1100 |
| 47 | 0.2374 | 0.2425 | 0.2425 | 0.2419 | 0.2419 | 0.2419 | 0.2419 | 0.2471 | 0.2471 | 0.2426 | 0.2426 | 0.2426 | 0.2426 | 0.2486 | 0.2486 |
| 48 | 0.1045 | 0.1075 | 0.1075 | 0.1060 | 0.1060 | 0.1060 | 0.1060 | 0.1091 | 0.1091 | 0.1050 | 0.1050 | 0.1050 | 0.1050 | 0.1086 | 0.1086 |
| 49 | 0.2227 | 0.2265 | 0.2265 | 0.2258 | 0.2258 | 0.2258 | 0.2258 | 0.2296 | 0.2296 | 0.2274 | 0.2274 | 0.2274 | 0.2274 | 0.2319 | 0.2319 |
| 50 | 0.1178 | 0.1201 | 0.1201 | 0.1210 | 0.1210 | 0.1210 | 0.1210 | 0.1234 | 0.1234 | 0.1225 | 0.1225 | 0.1225 | 0.1225 | 0.1255 | 0.1255 |

| **Harmonic Order** | **PQ31b** | **PQ32b** | **PQ33b** | **PQ34b** | **PQ35b** | **PQ36b** | **PQ37b** | **PQ38b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 1.7810 | 1.7810 | 1.8137 | 1.8137 | 1.8430 | 1.8430 | 1.7730 | 1.7730 |
| 2 | 0.4319 | 0.4319 | 0.4217 | 0.4217 | 0.4180 | 0.4180 | 0.3968 | 0.3968 |
| 3 | 0.2190 | 0.2190 | 0.2111 | 0.2111 | 0.2093 | 0.2093 | 0.2086 | 0.2086 |
| 4 | 0.2330 | 0.2330 | 0.2373 | 0.2373 | 0.2324 | 0.2324 | 0.2641 | 0.2641 |
| 5 | 0.8040 | 0.8040 | 0.7218 | 0.7218 | 0.7174 | 0.7174 | 0.7402 | 0.7402 |
| 6 | 0.1255 | 0.1255 | 0.1068 | 0.1068 | 0.1140 | 0.1140 | 0.1630 | 0.1630 |
| 7 | 0.3812 | 0.3812 | 0.4321 | 0.4321 | 0.4321 | 0.4321 | 0.3488 | 0.3488 |
| 8 | 0.1253 | 0.1253 | 0.1385 | 0.1385 | 0.1735 | 0.1735 | 0.1476 | 0.1476 |
| 9 | 0.1152 | 0.1152 | 0.1194 | 0.1194 | 0.1194 | 0.1194 | 0.1229 | 0.1229 |
| 10 | 0.1403 | 0.1403 | 0.1574 | 0.1574 | 0.1754 | 0.1754 | 0.1631 | 0.1631 |
| 11 | 0.2772 | 0.2772 | 0.3131 | 0.3131 | 0.3242 | 0.3242 | 0.3017 | 0.3017 |
| 12 | 0.0782 | 0.0782 | 0.0825 | 0.0825 | 0.0922 | 0.0922 | 0.1010 | 0.1010 |
| 13 | 0.2701 | 0.2701 | 0.3048 | 0.3048 | 0.3170 | 0.3170 | 0.2945 | 0.2945 |
| 14 | 0.1213 | 0.1213 | 0.1307 | 0.1307 | 0.1406 | 0.1406 | 0.1357 | 0.1357 |
| 15 | 0.1585 | 0.1585 | 0.1793 | 0.1793 | 0.1715 | 0.1715 | 0.1540 | 0.1540 |
| 16 | 0.1512 | 0.1512 | 0.1962 | 0.1962 | 0.2061 | 0.2061 | 0.1524 | 0.1524 |
| 17 | 0.4864 | 0.4864 | 0.6463 | 0.6463 | 0.6783 | 0.6783 | 0.5117 | 0.5117 |
| 18 | 0.1170 | 0.1170 | 0.1097 | 0.1097 | 0.1097 | 0.1097 | 0.1287 | 0.1287 |
| 19 | 0.4717 | 0.4717 | 0.4168 | 0.4168 | 0.4232 | 0.4232 | 0.5011 | 0.5011 |
| 20 | 0.1496 | 0.1496 | 0.1502 | 0.1502 | 0.1502 | 0.1502 | 0.1506 | 0.1506 |
| 21 | 0.1086 | 0.1086 | 0.1092 | 0.1092 | 0.1092 | 0.1092 | 0.1109 | 0.1109 |
| 22 | 0.1229 | 0.1229 | 0.1223 | 0.1223 | 0.1272 | 0.1272 | 0.1244 | 0.1244 |
| 23 | 0.4400 | 0.4400 | 0.4392 | 0.4392 | 0.4392 | 0.4392 | 0.4419 | 0.4419 |
| 24 | 0.1147 | 0.1147 | 0.1152 | 0.1152 | 0.1152 | 0.1152 | 0.1171 | 0.1171 |
| 25 | 0.3777 | 0.3777 | 0.3882 | 0.3882 | 0.3915 | 0.3915 | 0.3900 | 0.3900 |
| 26 | 0.1127 | 0.1127 | 0.1207 | 0.1207 | 0.1309 | 0.1309 | 0.1157 | 0.1157 |
| 27 | 0.1077 | 0.1077 | 0.1082 | 0.1082 | 0.1044 | 0.1044 | 0.1145 | 0.1145 |
| 28 | 0.1730 | 0.1730 | 0.1747 | 0.1747 | 0.1787 | 0.1787 | 0.1727 | 0.1727 |
| 29 | 0.4380 | 0.4380 | 0.4370 | 0.4370 | 0.4336 | 0.4336 | 0.4382 | 0.4382 |
| 30 | 0.1206 | 0.1206 | 0.1210 | 0.1210 | 0.1204 | 0.1204 | 0.1211 | 0.1211 |
| 31 | 0.3451 | 0.3451 | 0.3452 | 0.3452 | 0.3474 | 0.3474 | 0.3458 | 0.3458 |
| 32 | 0.1132 | 0.1132 | 0.1149 | 0.1149 | 0.1156 | 0.1156 | 0.1126 | 0.1126 |
| 33 | 0.0996 | 0.0996 | 0.1000 | 0.1000 | 0.1015 | 0.1015 | 0.0999 | 0.0999 |
| 34 | 0.1098 | 0.1098 | 0.1104 | 0.1104 | 0.1210 | 0.1210 | 0.1097 | 0.1097 |
| 35 | 0.2879 | 0.2879 | 0.2901 | 0.2901 | 0.2880 | 0.2880 | 0.2857 | 0.2857 |
| 36 | 0.1151 | 0.1151 | 0.1149 | 0.1149 | 0.1185 | 0.1185 | 0.1190 | 0.1190 |
| 37 | 0.2778 | 0.2778 | 0.2796 | 0.2796 | 0.3011 | 0.3011 | 0.2771 | 0.2771 |
| 38 | 0.1403 | 0.1403 | 0.1415 | 0.1415 | 0.1297 | 0.1297 | 0.1335 | 0.1335 |
| 39 | 0.1063 | 0.1063 | 0.1065 | 0.1065 | 0.1065 | 0.1065 | 0.1161 | 0.1161 |
| 40 | 0.1137 | 0.1137 | 0.1126 | 0.1126 | 0.1243 | 0.1243 | 0.1154 | 0.1154 |
| 41 | 0.2648 | 0.2648 | 0.2655 | 0.2655 | 0.2581 | 0.2581 | 0.2567 | 0.2567 |
| 42 | 0.1019 | 0.1019 | 0.1019 | 0.1019 | 0.1019 | 0.1019 | 0.1005 | 0.1005 |
| 43 | 0.2429 | 0.2429 | 0.2449 | 0.2449 | 0.2624 | 0.2624 | 0.2406 | 0.2406 |
| 44 | 0.1089 | 0.1089 | 0.1072 | 0.1072 | 0.1072 | 0.1072 | 0.1054 | 0.1054 |
| 45 | 0.1010 | 0.1010 | 0.1008 | 0.1008 | 0.1008 | 0.1008 | 0.1002 | 0.1002 |
| 46 | 0.1122 | 0.1122 | 0.1082 | 0.1082 | 0.1082 | 0.1082 | 0.1049 | 0.1049 |
| 47 | 0.2366 | 0.2366 | 0.2354 | 0.2354 | 0.2432 | 0.2432 | 0.2243 | 0.2243 |
| 48 | 0.1056 | 0.1056 | 0.1048 | 0.1048 | 0.1092 | 0.1092 | 0.1022 | 0.1022 |
| 49 | 0.2204 | 0.2204 | 0.2197 | 0.2197 | 0.2252 | 0.2252 | 0.2129 | 0.2129 |
| 50 | 0.1245 | 0.1245 | 0.1145 | 0.1145 | 0.1176 | 0.1176 | 0.1106 | 0.1106 |

## Plant Emissions

The voltage harmonic distortion (contribution from generating system) at the POC for each scenario considered.

### Without harmonic filters

| **Harmonic Order** | **PQ01a** | **PQ02a** | **PQ03a** | **PQ04a** | **PQ05a** | **PQ06a** | **PQ07a** | **PQ08a** | **PQ09a** | **PQ10a** | **PQ11a** | **PQ12a** | **PQ13a** | **PQ14a** | **PQ15a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 0.89 | 0.89 | 0.89 | 0.89 | 0.97 | 0.97 | 0.85 | 0.85 | 0.85 | 0.85 | 0.91 | 0.91 | 0.76 | 0.76 | 0.76 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| 8 | 0.05 | 0.05 | 0.05 | 0.05 | 0.08 | 0.08 | 0.05 | 0.05 | 0.05 | 0.05 | 0.07 | 0.07 | 0.05 | 0.05 | 0.05 |
| 9 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0 |
| 10 | 0.18 | 0.18 | 0.18 | 0.18 | 0.2 | 0.2 | 0.17 | 0.17 | 0.17 | 0.17 | 0.19 | 0.19 | 0.16 | 0.16 | 0.16 |
| 11 | 0.38 | 0.38 | 0.38 | 0.38 | 0.4 | 0.4 | 0.37 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | 0.35 | 0.35 | 0.35 |
| 12 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 |
| 13 | 0.37 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | 0.35 | 0.35 | 0.35 | 0.35 | 0.36 | 0.36 | 0.33 | 0.33 | 0.33 |
| 14 | 0.18 | 0.18 | 0.18 | 0.18 | 0.2 | 0.2 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.16 | 0.16 | 0.16 |
| 15 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 16 | 0.27 | 0.27 | 0.27 | 0.27 | 0.3 | 0.3 | 0.25 | 0.25 | 0.25 | 0.25 | 0.27 | 0.27 | 0.21 | 0.21 | 0.21 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0.07 | 0.07 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 28 | 0.11 | 0.11 | 0.11 | 0.11 | 0.13 | 0.13 | 0.11 | 0.11 | 0.11 | 0.11 | 0.13 | 0.13 | 0.1 | 0.1 | 0.1 |
| 29 | 0.13 | 0.13 | 0.13 | 0.13 | 0.11 | 0.11 | 0.13 | 0.13 | 0.13 | 0.13 | 0.11 | 0.11 | 0.13 | 0.13 | 0.13 |
| 30 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 31 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 32 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 |
| 33 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.03 | 0.03 | 0.03 | 0.03 | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.05 | 0.05 | 0.02 | 0.02 | 0.02 |
| 35 | 0.13 | 0.13 | 0.13 | 0.13 | 0.11 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 |
| 36 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.03 | 0.03 | 0.03 |
| 37 | 0.11 | 0.11 | 0.11 | 0.11 | 0.16 | 0.16 | 0.12 | 0.12 | 0.12 | 0.12 | 0.17 | 0.17 | 0.09 | 0.09 | 0.09 |
| 38 | 0.14 | 0.14 | 0.14 | 0.14 | 0.11 | 0.11 | 0.15 | 0.15 | 0.15 | 0.15 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 |
| 39 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 |
| 40 | 0.12 | 0.12 | 0.12 | 0.12 | 0.15 | 0.15 | 0.13 | 0.13 | 0.13 | 0.13 | 0.17 | 0.17 | 0.09 | 0.09 | 0.09 |
| 41 | 0.17 | 0.17 | 0.17 | 0.17 | 0.15 | 0.15 | 0.19 | 0.19 | 0.19 | 0.19 | 0.16 | 0.16 | 0.13 | 0.13 | 0.13 |
| 42 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.02 | 0.02 | 0.02 |
| 43 | 0.12 | 0.12 | 0.12 | 0.12 | 0.19 | 0.19 | 0.12 | 0.12 | 0.12 | 0.12 | 0.18 | 0.18 | 0.1 | 0.1 | 0.1 |
| 44 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.04 | 0.04 | 0.04 |
| 45 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 46 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.06 | 0.06 | 0.06 |
| 47 | 0.2 | 0.2 | 0.2 | 0.2 | 0.24 | 0.24 | 0.14 | 0.14 | 0.14 | 0.14 | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 |
| 48 | 0.06 | 0.06 | 0.06 | 0.06 | 0.09 | 0.09 | 0.02 | 0.02 | 0.02 | 0.02 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| 49 | 0.13 | 0.13 | 0.13 | 0.13 | 0.17 | 0.17 | 0.1 | 0.1 | 0.1 | 0.1 | 0.13 | 0.13 | 0.14 | 0.14 | 0.14 |
| 50 | 0.32 | 0.32 | 0.32 | 0.32 | 0.36 | 0.36 | 0.28 | 0.28 | 0.28 | 0.28 | 0.31 | 0.31 | 0.19 | 0.19 | 0.19 |

| **Harmonic Order** | **PQ16a** | **PQ17a** | **PQ18a** | **PQ19a** | **PQ20a** | **PQ21a** | **PQ22a** | **PQ23a** | **PQ24a** | **PQ25a** | **PQ26a** | **PQ27a** | **PQ28a** | **PQ29a** | **PQ30a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 0.76 | 0.82 | 0.82 | 0.89 | 0.89 | 0.89 | 0.89 | 0.96 | 0.96 | 0.88 | 0.88 | 0.88 | 0.88 | 0.97 | 0.97 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 |
| 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 | 0.17 |
| 8 | 0.05 | 0.08 | 0.08 | 0.05 | 0.05 | 0.05 | 0.05 | 0.08 | 0.08 | 0.05 | 0.05 | 0.05 | 0.05 | 0.08 | 0.08 |
| 9 | 0 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 10 | 0.16 | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.19 | 0.19 | 0.18 | 0.18 | 0.18 | 0.18 | 0.2 | 0.2 |
| 11 | 0.35 | 0.37 | 0.37 | 0.38 | 0.38 | 0.38 | 0.38 | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 | 0.39 | 0.41 | 0.41 |
| 12 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 |
| 13 | 0.33 | 0.34 | 0.34 | 0.37 | 0.37 | 0.37 | 0.37 | 0.38 | 0.38 | 0.37 | 0.37 | 0.37 | 0.37 | 0.39 | 0.39 |
| 14 | 0.16 | 0.17 | 0.17 | 0.19 | 0.19 | 0.19 | 0.19 | 0.2 | 0.2 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.19 |
| 15 | 0.11 | 0.1 | 0.1 | 0.14 | 0.14 | 0.14 | 0.14 | 0.12 | 0.12 | 0.13 | 0.13 | 0.13 | 0.13 | 0.12 | 0.12 |
| 16 | 0.21 | 0.22 | 0.22 | 0.28 | 0.28 | 0.28 | 0.28 | 0.31 | 0.31 | 0.26 | 0.26 | 0.26 | 0.26 | 0.28 | 0.28 |
| 17 | 0.07 | 0.12 | 0.12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.02 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0.01 | 0.01 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 28 | 0.1 | 0.12 | 0.12 | 0.1 | 0.1 | 0.1 | 0.1 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.14 | 0.14 |
| 29 | 0.13 | 0.11 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.1 | 0.1 | 0.15 | 0.15 | 0.15 | 0.15 | 0.13 | 0.13 |
| 30 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 31 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 |
| 32 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 33 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.02 | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.05 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.05 | 0.05 |
| 35 | 0.11 | 0.09 | 0.09 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 | 0.11 | 0.13 | 0.13 | 0.13 | 0.13 | 0.11 | 0.11 |
| 36 | 0.03 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 |
| 37 | 0.09 | 0.14 | 0.14 | 0.1 | 0.1 | 0.1 | 0.1 | 0.16 | 0.16 | 0.11 | 0.11 | 0.11 | 0.11 | 0.17 | 0.17 |
| 38 | 0.12 | 0.09 | 0.09 | 0.13 | 0.13 | 0.13 | 0.13 | 0.11 | 0.11 | 0.15 | 0.15 | 0.15 | 0.15 | 0.12 | 0.12 |
| 39 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 40 | 0.09 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.15 | 0.15 | 0.12 | 0.12 | 0.12 | 0.12 | 0.16 | 0.16 |
| 41 | 0.13 | 0.12 | 0.12 | 0.17 | 0.17 | 0.17 | 0.17 | 0.15 | 0.15 | 0.18 | 0.18 | 0.18 | 0.18 | 0.16 | 0.16 |
| 42 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 43 | 0.1 | 0.15 | 0.15 | 0.12 | 0.12 | 0.12 | 0.12 | 0.19 | 0.19 | 0.12 | 0.12 | 0.12 | 0.12 | 0.19 | 0.19 |
| 44 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 45 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 46 | 0.06 | 0.06 | 0.06 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 47 | 0.17 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.25 | 0.25 | 0.19 | 0.19 | 0.19 | 0.19 | 0.24 | 0.24 |
| 48 | 0.05 | 0.07 | 0.07 | 0.05 | 0.05 | 0.05 | 0.05 | 0.09 | 0.09 | 0.06 | 0.06 | 0.06 | 0.06 | 0.09 | 0.09 |
| 49 | 0.14 | 0.16 | 0.16 | 0.13 | 0.13 | 0.13 | 0.13 | 0.17 | 0.17 | 0.13 | 0.13 | 0.13 | 0.13 | 0.17 | 0.17 |
| 50 | 0.19 | 0.22 | 0.22 | 0.32 | 0.32 | 0.32 | 0.32 | 0.35 | 0.35 | 0.27 | 0.27 | 0.27 | 0.27 | 0.31 | 0.31 |

| **Harmonic Order** | **PQ31a** | **PQ32a** | **PQ33a** | **PQ34a** | **PQ35a** | **PQ36a** | **PQ37a** | **PQ38a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 0.9 | 0.9 | 0.41 | 0.41 | 0.47 | 0.47 | 0.66 | 0.66 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.07 | 0.07 |
| 5 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.02 |
| 7 | 0.14 | 0.14 | 0.1 | 0.1 | 0.1 | 0.1 | 0.08 | 0.08 |
| 8 | 0.04 | 0.04 | 0.03 | 0.03 | 0.06 | 0.06 | 0.06 | 0.06 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.02 |
| 10 | 0.14 | 0.14 | 0.1 | 0.1 | 0.12 | 0.12 | 0.17 | 0.17 |
| 11 | 0.29 | 0.29 | 0.2 | 0.2 | 0.22 | 0.22 | 0.3 | 0.3 |
| 12 | 0.04 | 0.04 | 0.02 | 0.02 | 0.03 | 0.03 | 0.07 | 0.07 |
| 13 | 0.24 | 0.24 | 0.16 | 0.16 | 0.18 | 0.18 | 0.29 | 0.29 |
| 14 | 0.11 | 0.11 | 0.07 | 0.07 | 0.08 | 0.08 | 0.14 | 0.14 |
| 15 | 0.08 | 0.08 | 0.04 | 0.04 | 0.03 | 0.03 | 0.12 | 0.12 |
| 16 | 0.14 | 0.14 | 0.06 | 0.06 | 0.07 | 0.07 | 0.25 | 0.25 |
| 17 | 0.5 | 0.5 | 0.18 | 0.18 | 0.21 | 0.21 | 0 | 0 |
| 18 | 0 | 0 | 0.08 | 0.08 | 0.08 | 0.08 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 22 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.01 | 0 | 0 |
| 27 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 |
| 28 | 0.11 | 0.11 | 0.08 | 0.08 | 0.1 | 0.1 | 0.11 | 0.11 |
| 29 | 0.1 | 0.1 | 0.09 | 0.09 | 0.07 | 0.07 | 0.1 | 0.1 |
| 30 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 |
| 31 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 |
| 32 | 0.05 | 0.05 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 33 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.06 | 0.06 | 0.01 | 0.01 | 0.04 | 0.04 | 0.02 | 0.02 |
| 35 | 0.42 | 0.42 | 0.05 | 0.05 | 0.03 | 0.03 | 0.06 | 0.06 |
| 36 | 0.04 | 0.04 | 0.01 | 0.01 | 0.03 | 0.03 | 0.08 | 0.08 |
| 37 | 0.11 | 0.11 | 0.04 | 0.04 | 0.08 | 0.08 | 0.11 | 0.11 |
| 38 | 0.25 | 0.25 | 0.06 | 0.06 | 0.03 | 0.03 | 0.07 | 0.07 |
| 39 | 0.09 | 0.09 | 0.01 | 0.01 | 0.01 | 0.01 | 0.07 | 0.07 |
| 40 | 0.11 | 0.11 | 0.03 | 0.03 | 0.05 | 0.05 | 0.14 | 0.14 |
| 41 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.08 | 0.08 |
| 42 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 43 | 0.05 | 0.05 | 0.03 | 0.03 | 0.06 | 0.06 | 0.05 | 0.05 |
| 44 | 0.14 | 0.14 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 45 | 0.02 | 0.02 | 0 | 0 | 0 | 0 | 0.01 | 0.01 |
| 46 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.06 | 0.06 |
| 47 | 0.03 | 0.03 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.06 |
| 48 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 49 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.02 | 0.02 |
| 50 | 0.06 | 0.06 | 0.03 | 0.03 | 0.03 | 0.03 | 0.14 | 0.14 |

### With harmonic filters in service

| **Harmonic Order** | **PQ01b** | **PQ02b** | **PQ03b** | **PQ04b** | **PQ05b** | **PQ06b** | **PQ07b** | **PQ08b** | **PQ09b** | **PQ10b** | **PQ11b** | **PQ12b** | **PQ13b** | **PQ14b** | **PQ15b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 0.31 | 0.31 | 0.31 | 0.31 | 0.33 | 0.33 | 0.28 | 0.28 | 0.28 | 0.28 | 0.3 | 0.3 | 0.28 | 0.28 | 0.28 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 |
| 5 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.06 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| 6 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 |
| 7 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 8 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.04 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 | 0.01 | 0.01 | 0.01 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 |
| 11 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 | 0.15 | 0.15 | 0.15 |
| 12 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 13 | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 | 0.13 | 0.13 | 0.13 | 0.13 | 0.14 | 0.14 | 0.13 | 0.13 | 0.13 |
| 14 | 0.09 | 0.09 | 0.09 | 0.09 | 0.1 | 0.1 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 |
| 15 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.01 | 0.01 |
| 16 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 29 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| 30 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 |
| 38 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 40 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 41 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 44 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 47 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 |
| 48 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0 |
| 49 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 |
| 50 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |

| **Harmonic Order** | **PQ16b** | **PQ17b** | **PQ18b** | **PQ19b** | **PQ20b** | **PQ21b** | **PQ22b** | **PQ23b** | **PQ24b** | **PQ25b** | **PQ26b** | **PQ27b** | **PQ28b** | **PQ29b** | **PQ30b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 0.28 | 0.29 | 0.29 | 0.3 | 0.3 | 0.3 | 0.3 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.32 | 0.34 | 0.34 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.06 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 5 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 6 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 7 | 0.06 | 0.06 | 0.06 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 |
| 8 | 0.01 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.04 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.04 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 |
| 11 | 0.15 | 0.16 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 | 0.18 |
| 12 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 13 | 0.13 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 |
| 14 | 0.08 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.1 | 0.1 |
| 15 | 0.01 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 16 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 17 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 | 0.08 |
| 29 | 0.09 | 0.09 | 0.09 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.07 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| 30 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 | 0 | 0 | 0.01 | 0.01 |
| 38 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 40 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 41 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 44 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 47 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 48 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 49 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 50 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |

| **Harmonic Order** | **PQ31b** | **PQ32b** | **PQ33b** | **PQ34b** | **PQ35b** | **PQ36b** | **PQ37b** | **PQ38b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| THD | 0.22 | 0.22 | 0.28 | 0.28 | 0.3 | 0.3 | 0.24 | 0.24 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.07 | 0.07 |
| 5 | 0.09 | 0.09 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 |
| 6 | 0.02 | 0.02 | 0 | 0 | 0.01 | 0.01 | 0.06 | 0.06 |
| 7 | 0.04 | 0.04 | 0.09 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 8 | 0 | 0 | 0.02 | 0.02 | 0.05 | 0.05 | 0.03 | 0.03 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0.05 | 0.05 | 0.07 | 0.07 | 0.08 | 0.08 | 0.07 | 0.07 |
| 11 | 0.1 | 0.1 | 0.14 | 0.14 | 0.15 | 0.15 | 0.12 | 0.12 |
| 12 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 |
| 13 | 0.08 | 0.08 | 0.12 | 0.12 | 0.13 | 0.13 | 0.1 | 0.1 |
| 14 | 0.05 | 0.05 | 0.06 | 0.06 | 0.07 | 0.07 | 0.06 | 0.06 |
| 15 | 0.01 | 0.01 | 0.03 | 0.03 | 0.02 | 0.02 | 0 | 0 |
| 16 | 0.01 | 0.01 | 0.06 | 0.06 | 0.07 | 0.07 | 0.01 | 0.01 |
| 17 | 0 | 0 | 0.05 | 0.05 | 0.08 | 0.08 | 0 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 21 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 26 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 | 0.01 | 0.01 |
| 28 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 29 | 0.09 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.09 | 0.09 |
| 30 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 32 | 0 | 0 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 |
| 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 34 | 0 | 0 | 0 | 0 | 0.01 | 0.01 | 0 | 0 |
| 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37 | 0 | 0 | 0 | 0 | 0.03 | 0.03 | 0 | 0 |
| 38 | 0.04 | 0.04 | 0.04 | 0.04 | 0.02 | 0.02 | 0.03 | 0.03 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 40 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 |
| 41 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 43 | 0.01 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 | 0 | 0 |
| 44 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 |
| 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 46 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 |
| 47 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.01 | 0.01 |
| 48 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0 | 0 |
| 49 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0 | 0 |
| 50 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 |

## Amplification Factors

The amplification factors for each scenario considered covering all harmonic orders.

### Without harmonic filters

| **Harmonic Order** | **PQ01a** | **PQ02a** | **PQ03a** | **PQ04a** | **PQ05a** | **PQ06a** | **PQ07a** | **PQ08a** | **PQ09a** | **PQ10a** | **PQ11a** | **PQ12a** | **PQ13a** | **PQ14a** | **PQ15a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.76 | 0.76 | 0.76 |
| 3 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| 4 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.15 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 |
| 5 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| 6 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| 7 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 |
| 8 | 0.97 | 0.97 | 0.97 | 0.97 | 0.86 | 0.86 | 0.97 | 0.97 | 0.97 | 0.97 | 0.87 | 0.87 | 0.97 | 0.97 | 0.97 |
| 9 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 10 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.83 | 0.83 | 0.83 |
| 11 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 |
| 12 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.92 | 0.92 | 0.92 |
| 13 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 |
| 14 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 |
| 15 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.06 | 1.06 | 1.06 |
| 16 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.35 | 1.37 | 1.37 | 1.37 | 1.37 | 1.37 | 1.37 | 1.30 | 1.30 | 1.30 |
| 17 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.80 | 0.80 | 0.80 |
| 18 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.72 | 0.68 | 0.68 | 0.68 |
| 19 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.80 | 0.80 | 0.80 |
| 20 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.92 |
| 21 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.06 | 1.06 | 1.06 |
| 22 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.96 | 0.96 | 0.98 | 0.98 | 0.98 |
| 23 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 24 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| 25 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 26 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |
| 27 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 28 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 29 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 |
| 30 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.03 |
| 31 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.02 | 1.02 | 1.02 |
| 32 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 |
| 33 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 34 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 |
| 35 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.95 | 0.95 | 0.95 |
| 36 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.93 | 0.93 | 0.93 |
| 37 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 | 0.96 |
| 38 | 0.92 | 0.92 | 0.92 | 0.92 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 0.94 | 0.94 | 0.94 |
| 39 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 |
| 40 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.06 | 1.06 | 1.06 |
| 41 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.97 | 0.97 | 0.97 |
| 42 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 |
| 43 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.98 | 0.98 | 0.98 |
| 44 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.88 | 0.88 | 0.88 |
| 45 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 |
| 46 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.09 | 1.09 | 1.09 |
| 47 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.42 | 0.92 | 0.92 | 0.92 |
| 48 | 0.79 | 0.79 | 0.79 | 0.79 | 0.75 | 0.75 | 0.56 | 0.56 | 0.56 | 0.56 | 0.52 | 0.52 | 1.06 | 1.06 | 1.06 |
| 49 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.47 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.52 | 0.87 | 0.87 | 0.87 |
| 50 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.07 | 1.07 | 1.07 |

| **Harmonic Order** | **PQ16a** | **PQ17a** | **PQ18a** | **PQ19a** | **PQ20a** | **PQ21a** | **PQ22a** | **PQ23a** | **PQ24a** | **PQ25a** | **PQ26a** | **PQ27a** | **PQ28a** | **PQ29a** | **PQ30a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| 3 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 |
| 4 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.16 | 1.16 | 1.16 | 1.16 | 1.16 | 1.16 |
| 5 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 |
| 6 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 |
| 7 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 |
| 8 | 0.97 | 0.87 | 0.87 | 0.97 | 0.97 | 0.97 | 0.97 | 0.87 | 0.87 | 0.97 | 0.97 | 0.97 | 0.97 | 0.86 | 0.86 |
| 9 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 10 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| 11 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 12 | 0.92 | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| 13 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 14 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 15 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 16 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.37 | 1.37 | 1.37 | 1.37 | 1.37 | 1.37 |
| 17 | 0.80 | 0.80 | 0.80 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.82 | 0.82 | 0.82 | 0.82 | 0.65 | 0.65 |
| 18 | 0.68 | 0.68 | 0.68 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| 19 | 0.80 | 0.80 | 0.80 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| 20 | 0.92 | 0.92 | 0.92 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 21 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 22 | 0.98 | 0.96 | 0.96 | 0.99 | 0.99 | 0.99 | 0.99 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 |
| 23 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 24 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 25 | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 26 | 0.91 | 0.91 | 0.91 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| 27 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 28 | 1.03 | 1.03 | 1.03 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.07 | 1.07 | 1.07 | 1.07 | 1.01 | 1.01 |
| 29 | 1.11 | 1.11 | 1.11 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.14 | 1.14 | 1.14 | 1.14 | 1.17 | 1.17 |
| 30 | 1.03 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 31 | 1.02 | 1.02 | 1.02 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 |
| 32 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 33 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 34 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 35 | 0.95 | 0.95 | 0.95 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 36 | 0.93 | 0.93 | 0.93 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| 37 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 38 | 0.94 | 0.94 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 39 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 40 | 1.06 | 1.06 | 1.06 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.10 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 |
| 41 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| 42 | 1.03 | 1.03 | 1.03 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 43 | 0.98 | 0.98 | 0.98 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 44 | 0.88 | 0.88 | 0.88 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 |
| 45 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 46 | 1.09 | 1.09 | 1.09 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 | 1.14 |
| 47 | 0.92 | 0.92 | 0.92 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 |
| 48 | 1.06 | 1.06 | 1.06 | 0.72 | 0.72 | 0.72 | 0.72 | 0.68 | 0.68 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 |
| 49 | 0.87 | 0.87 | 0.87 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 | 0.49 |
| 50 | 1.07 | 1.07 | 1.07 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 |

| **Harmonic Order** | **PQ31a** | **PQ32a** | **PQ33a** | **PQ34a** | **PQ35a** | **PQ36a** | **PQ37a** | **PQ38a** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.83 | 0.83 | 0.82 | 0.82 | 0.82 | 0.82 | 0.76 | 0.76 |
| 3 | 0.85 | 0.85 | 0.83 | 0.83 | 0.83 | 0.83 | 0.77 | 0.77 |
| 4 | 1.09 | 1.09 | 1.10 | 1.10 | 1.10 | 1.10 | 1.15 | 1.15 |
| 5 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 | 0.94 | 0.91 | 0.91 |
| 6 | 0.94 | 0.94 | 0.92 | 0.92 | 0.92 | 0.92 | 0.88 | 0.88 |
| 7 | 0.90 | 0.90 | 0.87 | 0.87 | 0.87 | 0.87 | 0.81 | 0.81 |
| 8 | 0.93 | 0.93 | 0.98 | 0.98 | 0.90 | 0.90 | 0.86 | 0.86 |
| 9 | 0.94 | 0.94 | 1.00 | 1.00 | 1.00 | 1.00 | 0.86 | 0.86 |
| 10 | 0.94 | 0.94 | 0.87 | 0.87 | 0.87 | 0.87 | 0.83 | 0.83 |
| 11 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.95 | 0.95 |
| 12 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 0.93 | 0.93 |
| 13 | 1.01 | 1.01 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 14 | 1.04 | 1.04 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 |
| 15 | 1.11 | 1.11 | 1.02 | 1.02 | 1.02 | 1.02 | 1.07 | 1.07 |
| 16 | 1.34 | 1.34 | 1.05 | 1.05 | 1.05 | 1.05 | 1.35 | 1.35 |
| 17 | 1.55 | 1.55 | 1.20 | 1.20 | 1.20 | 1.20 | 0.72 | 0.72 |
| 18 | 0.53 | 0.53 | 1.18 | 1.18 | 1.18 | 1.18 | 0.75 | 0.75 |
| 19 | 0.63 | 0.63 | 0.73 | 0.73 | 0.73 | 0.73 | 0.83 | 0.83 |
| 20 | 0.96 | 0.96 | 0.81 | 0.81 | 0.81 | 0.81 | 0.94 | 0.94 |
| 21 | 1.07 | 1.07 | 1.05 | 1.05 | 1.05 | 1.05 | 0.98 | 0.98 |
| 22 | 0.96 | 0.96 | 0.95 | 0.95 | 0.92 | 0.92 | 0.98 | 0.98 |
| 23 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 |
| 24 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 |
| 25 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 26 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.91 | 0.91 |
| 27 | 0.99 | 0.99 | 1.01 | 1.01 | 1.02 | 1.02 | 1.01 | 1.01 |
| 28 | 0.97 | 0.97 | 1.04 | 1.04 | 1.04 | 1.04 | 1.03 | 1.03 |
| 29 | 1.01 | 1.01 | 1.10 | 1.10 | 1.12 | 1.12 | 1.14 | 1.14 |
| 30 | 0.98 | 0.98 | 1.02 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 |
| 31 | 0.99 | 0.99 | 1.01 | 1.01 | 1.01 | 1.01 | 1.02 | 1.02 |
| 32 | 1.00 | 1.00 | 0.98 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 |
| 33 | 1.00 | 1.00 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 34 | 1.10 | 1.10 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 35 | 1.45 | 1.45 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 |
| 36 | 0.95 | 0.95 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 37 | 1.17 | 1.17 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| 38 | 1.35 | 1.35 | 0.97 | 0.97 | 0.97 | 0.97 | 1.00 | 1.00 |
| 39 | 1.30 | 1.30 | 0.98 | 0.98 | 0.98 | 0.98 | 1.00 | 1.00 |
| 40 | 0.51 | 0.51 | 1.02 | 1.02 | 1.02 | 1.02 | 1.09 | 1.09 |
| 41 | 0.74 | 0.74 | 0.98 | 0.98 | 0.98 | 0.98 | 0.96 | 0.96 |
| 42 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.04 | 1.04 |
| 43 | 1.01 | 1.01 | 0.99 | 0.99 | 0.99 | 0.99 | 0.96 | 0.96 |
| 44 | 1.31 | 1.31 | 0.94 | 0.94 | 0.94 | 0.94 | 0.83 | 0.83 |
| 45 | 1.09 | 1.09 | 1.01 | 1.01 | 1.01 | 1.01 | 1.02 | 1.02 |
| 46 | 1.01 | 1.01 | 1.04 | 1.04 | 1.04 | 1.04 | 1.14 | 1.14 |
| 47 | 0.83 | 0.83 | 0.99 | 0.99 | 0.99 | 0.99 | 0.81 | 0.81 |
| 48 | 1.01 | 1.01 | 1.03 | 1.03 | 1.03 | 1.03 | 0.79 | 0.79 |
| 49 | 0.88 | 0.88 | 0.99 | 0.99 | 0.99 | 0.99 | 0.93 | 0.93 |
| 50 | 1.08 | 1.08 | 1.04 | 1.04 | 1.04 | 1.04 | 0.81 | 0.81 |

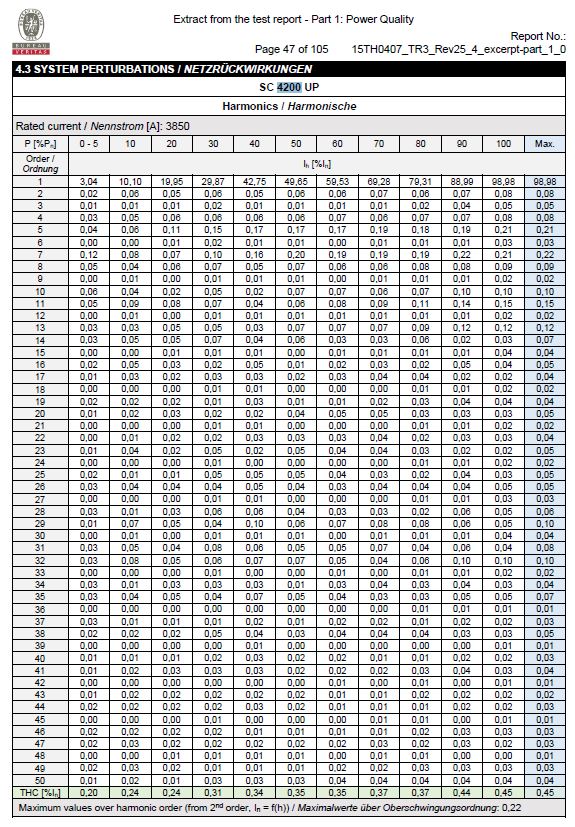
### With harmonic filters in service

| **Harmonic Order** | **PQ01b** | **PQ02b** | **PQ03b** | **PQ04b** | **PQ05b** | **PQ06b** | **PQ07b** | **PQ08b** | **PQ09b** | **PQ10b** | **PQ11b** | **PQ12b** | **PQ13b** | **PQ14b** | **PQ15b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.76 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 |
| 3 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.79 | 0.79 | 0.79 |
| 4 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 |
| 5 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.83 | 0.83 | 0.83 |
| 6 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.86 | 0.86 | 0.86 | 0.86 | 0.80 | 0.80 | 0.86 | 0.86 | 0.86 |
| 7 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 |
| 8 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.81 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.80 | 0.81 | 0.81 | 0.81 |
| 9 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 |
| 10 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 | 0.61 |
| 11 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |
| 12 | 1.04 | 1.04 | 1.04 | 1.04 | 0.81 | 0.81 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.04 | 1.04 | 1.04 |
| 13 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.67 | 0.67 | 0.67 |
| 14 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.71 | 0.73 | 0.73 | 0.73 |
| 15 | 0.74 | 0.74 | 0.74 | 0.74 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.75 | 0.75 | 0.75 |
| 16 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| 17 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |
| 18 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 |
| 19 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.90 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 | 0.89 |
| 20 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| 21 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| 22 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 23 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 24 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 25 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.93 | 0.93 | 0.93 |
| 26 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 | 0.86 |
| 27 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 28 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 |
| 29 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 |
| 30 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 | 1.09 |
| 31 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 |
| 32 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 33 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 34 | 0.99 | 0.99 | 0.99 | 0.99 | 0.92 | 0.92 | 0.99 | 0.99 | 0.99 | 0.99 | 0.92 | 0.92 | 0.99 | 0.99 | 0.99 |
| 35 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 36 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 |
| 37 | 0.98 | 0.98 | 0.98 | 0.98 | 0.90 | 0.90 | 0.98 | 0.98 | 0.98 | 0.98 | 0.90 | 0.90 | 0.98 | 0.98 | 0.98 |
| 38 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| 39 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| 40 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 | 0.92 | 1.00 | 1.00 | 1.00 | 1.00 | 0.92 | 0.92 | 1.00 | 1.00 | 1.00 |
| 41 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 42 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 |
| 43 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.99 | 0.99 | 0.99 |
| 44 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 45 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 |
| 46 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 47 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 |
| 48 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 49 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 |
| 50 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 |

| **Harmonic Order** | **PQ16b** | **PQ17b** | **PQ18b** | **PQ19b** | **PQ20b** | **PQ21b** | **PQ22b** | **PQ23b** | **PQ24b** | **PQ25b** | **PQ26b** | **PQ27b** | **PQ28b** | **PQ29b** | **PQ30b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.77 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| 3 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 | 0.78 |
| 4 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 | 1.12 |
| 5 | 0.83 | 0.83 | 0.83 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 6 | 0.86 | 0.80 | 0.80 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| 7 | 0.55 | 0.55 | 0.55 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.57 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 | 0.55 |
| 8 | 0.81 | 0.81 | 0.81 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| 9 | 0.94 | 0.94 | 0.94 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 10 | 0.61 | 0.61 | 0.61 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.63 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 | 0.60 |
| 11 | 0.67 | 0.67 | 0.67 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.69 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 | 0.66 |
| 12 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 0.83 | 0.83 | 1.03 | 1.03 | 1.03 | 1.03 | 0.80 | 0.80 |
| 13 | 0.67 | 0.67 | 0.67 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.68 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 | 0.65 |
| 14 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.73 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 | 0.70 |
| 15 | 0.75 | 0.84 | 0.84 | 0.75 | 0.75 | 0.75 | 0.75 | 0.83 | 0.83 | 0.74 | 0.74 | 0.74 | 0.74 | 0.83 | 0.83 |
| 16 | 0.75 | 0.75 | 0.75 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.71 | 0.71 | 0.71 | 0.71 | 0.70 | 0.70 |
| 17 | 0.82 | 0.82 | 0.82 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 | 0.79 |
| 18 | 0.90 | 0.90 | 0.90 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 |
| 19 | 0.89 | 0.89 | 0.89 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.91 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 | 0.87 |
| 20 | 1.05 | 1.05 | 1.05 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| 21 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 |
| 22 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 23 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 24 | 0.95 | 0.95 | 0.95 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 25 | 0.93 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| 26 | 0.86 | 0.86 | 0.86 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.88 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 | 0.84 |
| 27 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 |
| 28 | 1.48 | 1.48 | 1.48 | 1.39 | 1.39 | 1.39 | 1.39 | 1.39 | 1.39 | 1.60 | 1.60 | 1.60 | 1.60 | 1.60 | 1.60 |
| 29 | 1.24 | 1.24 | 1.24 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 | 1.30 |
| 30 | 1.09 | 1.09 | 1.09 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.07 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 | 1.11 |
| 31 | 1.04 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 | 1.05 |
| 32 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 0.98 | 0.98 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 33 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 34 | 0.99 | 0.92 | 0.92 | 0.99 | 0.99 | 0.99 | 0.99 | 0.94 | 0.94 | 0.98 | 0.98 | 0.98 | 0.98 | 0.91 | 0.91 |
| 35 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 |
| 36 | 1.04 | 1.04 | 1.04 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 | 1.06 |
| 37 | 0.98 | 0.90 | 0.90 | 0.99 | 0.99 | 0.99 | 0.99 | 0.92 | 0.92 | 0.98 | 0.98 | 0.98 | 0.98 | 0.88 | 0.88 |
| 38 | 1.06 | 1.09 | 1.09 | 1.01 | 1.01 | 1.01 | 1.01 | 1.03 | 1.03 | 1.09 | 1.09 | 1.09 | 1.09 | 1.13 | 1.13 |
| 39 | 1.05 | 1.05 | 1.05 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.03 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 | 1.08 |
| 40 | 1.00 | 0.92 | 0.92 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 |
| 41 | 0.93 | 1.01 | 1.01 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.92 | 0.92 | 0.92 | 0.92 | 1.02 | 1.02 |
| 42 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| 43 | 0.99 | 0.93 | 0.93 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.94 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 | 0.92 |
| 44 | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 45 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 46 | 1.00 | 1.00 | 1.00 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| 47 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 48 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| 49 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 50 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.00 | 1.00 | 1.00 | 1.00 | 0.94 | 0.94 |

| **Harmonic Order** | **PQ31b** | **PQ32b** | **PQ33b** | **PQ34b** | **PQ35b** | **PQ36b** | **PQ37b** | **PQ38b** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 2 | 0.84 | 0.84 | 0.82 | 0.82 | 0.82 | 0.82 | 0.76 | 0.76 |
| 3 | 0.87 | 0.87 | 0.84 | 0.84 | 0.84 | 0.84 | 0.78 | 0.78 |
| 4 | 1.05 | 1.05 | 1.09 | 1.09 | 1.09 | 1.09 | 1.12 | 1.12 |
| 5 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.94 | 0.94 |
| 6 | 0.98 | 0.98 | 0.85 | 0.85 | 0.85 | 0.85 | 0.79 | 0.79 |
| 7 | 0.77 | 0.77 | 0.78 | 0.78 | 0.78 | 0.78 | 0.71 | 0.71 |
| 8 | 0.80 | 0.80 | 0.83 | 0.83 | 0.83 | 0.83 | 0.81 | 0.81 |
| 9 | 0.93 | 0.93 | 0.96 | 0.96 | 0.96 | 0.96 | 0.93 | 0.93 |
| 10 | 0.65 | 0.65 | 0.75 | 0.75 | 0.75 | 0.75 | 0.61 | 0.61 |
| 11 | 0.63 | 0.63 | 0.81 | 0.81 | 0.81 | 0.81 | 0.67 | 0.67 |
| 12 | 0.98 | 0.98 | 0.91 | 0.91 | 0.90 | 0.90 | 0.81 | 0.81 |
| 13 | 0.67 | 0.67 | 0.83 | 0.83 | 0.83 | 0.83 | 0.67 | 0.67 |
| 14 | 0.70 | 0.70 | 0.88 | 0.88 | 0.88 | 0.88 | 0.71 | 0.71 |
| 15 | 0.89 | 0.89 | 0.99 | 0.99 | 0.99 | 0.99 | 0.83 | 0.83 |
| 16 | 0.76 | 0.76 | 1.05 | 1.05 | 1.05 | 1.05 | 0.75 | 0.75 |
| 17 | 0.78 | 0.78 | 0.97 | 0.97 | 0.97 | 0.97 | 0.82 | 0.82 |
| 18 | 0.84 | 0.84 | 0.74 | 0.74 | 0.74 | 0.74 | 0.90 | 0.90 |
| 19 | 0.85 | 0.85 | 0.72 | 0.72 | 0.72 | 0.72 | 0.90 | 0.90 |
| 20 | 1.04 | 1.04 | 0.97 | 0.97 | 0.97 | 0.97 | 1.06 | 1.06 |
| 21 | 1.07 | 1.07 | 1.06 | 1.06 | 1.06 | 1.06 | 1.01 | 1.01 |
| 22 | 0.98 | 0.98 | 0.96 | 0.96 | 0.96 | 0.96 | 0.99 | 0.99 |
| 23 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 |
| 24 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| 25 | 0.90 | 0.90 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 | 0.93 |
| 26 | 0.88 | 0.88 | 0.85 | 0.85 | 0.74 | 0.74 | 0.88 | 0.88 |
| 27 | 1.03 | 1.03 | 0.97 | 0.97 | 0.97 | 0.97 | 1.03 | 1.03 |
| 28 | 1.49 | 1.49 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 | 1.48 |
| 29 | 1.24 | 1.24 | 1.22 | 1.22 | 1.22 | 1.22 | 1.24 | 1.24 |
| 30 | 1.09 | 1.09 | 1.08 | 1.08 | 1.08 | 1.08 | 1.09 | 1.09 |
| 31 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 | 1.04 |
| 32 | 1.01 | 1.01 | 0.98 | 0.98 | 0.98 | 0.98 | 1.01 | 1.01 |
| 33 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 | 0.99 | 0.99 |
| 34 | 0.99 | 0.99 | 0.99 | 0.99 | 0.94 | 0.94 | 0.99 | 0.99 |
| 35 | 0.98 | 0.98 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 |
| 36 | 1.03 | 1.03 | 1.03 | 1.03 | 0.97 | 0.97 | 0.97 | 0.97 |
| 37 | 0.98 | 0.98 | 0.92 | 0.92 | 0.92 | 0.92 | 0.98 | 0.98 |
| 38 | 1.02 | 1.02 | 1.00 | 1.00 | 1.05 | 1.05 | 1.09 | 1.09 |
| 39 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.02 | 1.05 | 1.05 |
| 40 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.92 | 0.92 |
| 41 | 0.92 | 0.92 | 0.94 | 0.94 | 0.94 | 0.94 | 1.01 | 1.01 |
| 42 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 1.00 | 1.00 |
| 43 | 0.93 | 0.93 | 0.95 | 0.95 | 0.95 | 0.95 | 0.99 | 0.99 |
| 44 | 0.96 | 0.96 | 0.97 | 0.97 | 0.97 | 0.97 | 0.99 | 0.99 |
| 45 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| 46 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.01 | 1.00 | 1.00 |
| 47 | 0.91 | 0.91 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 | 0.96 |
| 48 | 0.99 | 0.99 | 1.00 | 1.00 | 1.00 | 1.00 | 0.99 | 0.99 |
| 49 | 0.91 | 0.91 | 0.97 | 0.97 | 0.97 | 0.97 | 0.95 | 0.95 |
| 50 | 1.00 | 1.00 | 1.02 | 1.02 | 1.02 | 1.02 | 1.00 | 1.00 |

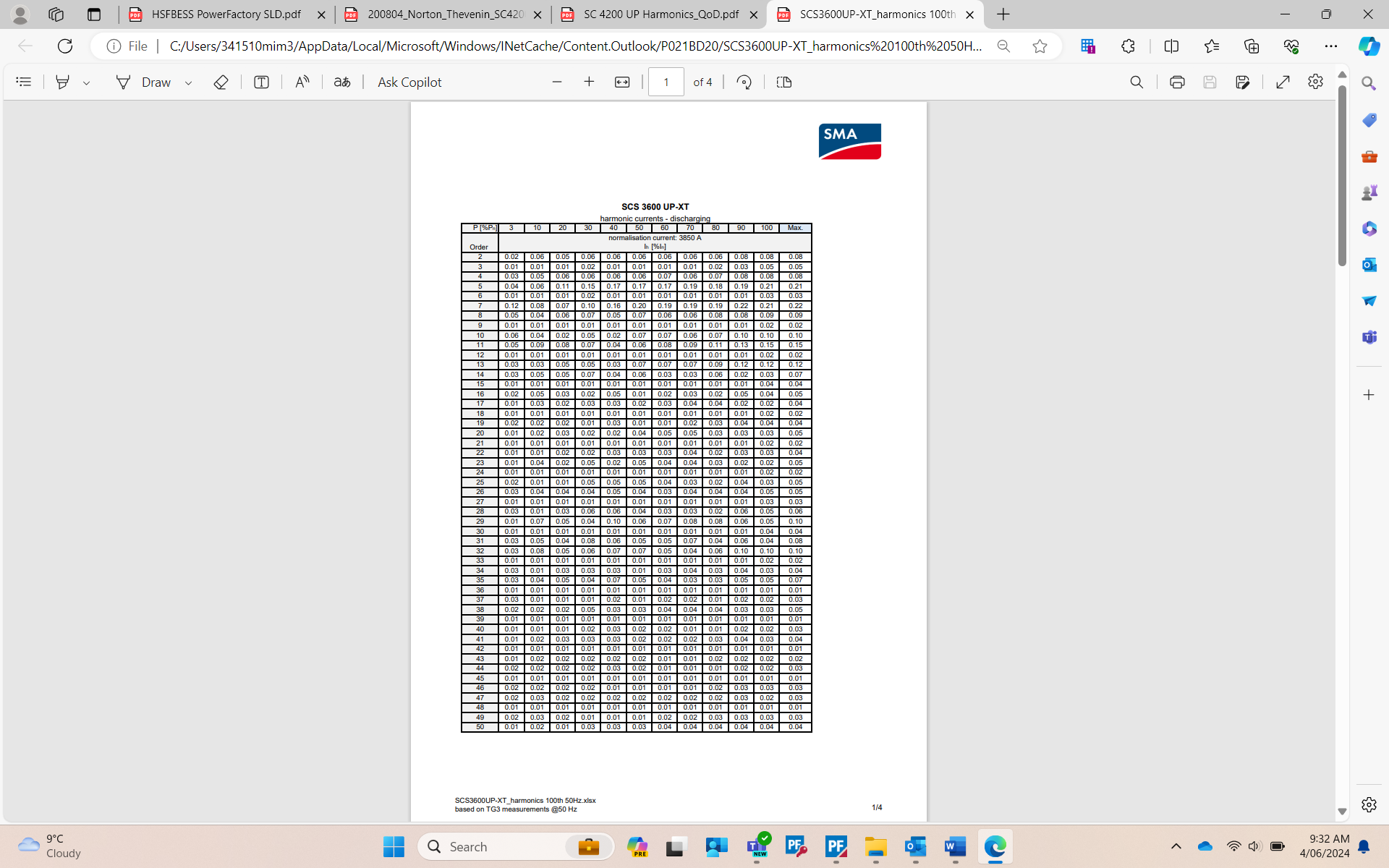
## PV Inverter Harmonic Current Injection Information



## PV Inverter “Q at Night Mode” Harmonic Current Injection Information

## A screenshot of a computer Description automatically generated

## BESS Inverter Harmonic Current Injection Information



A screenshot of a computer

Description automatically generated