Certificate

# Unit certificate for solar inverters

Certificate number: MOE 09-0326-14

Original ☒ 2013-08-07 1 of 4

**This certificate replaces certificate number MOE 09-0326-11.**

**For restrictions and conditions of validity, refer to chapter 5.**

Manufacturer

Power One Italy S.p.A
Via S. Giorgio
52028 Terranuova Bracciolini (AR)
Italy

**Scope**

Products: Central solar inverters
PVI-xxx.x-TL-DE and PVI-xxx.x-DE series
55, 110, 165, 220, 275 or 330 kW

Standards/Guidelines: BDEW technical guideline, Generating Plants connected to the Medium-Voltage Network, 2008 and supplement 7/2010
FGW TR3 Rev. 21; FGW TR4 Rev. 05

Certification system: FGW TR8 Rev. 04

Valid from: 2013-08-07
Valid until: 2015-12-22

DAkkS Deutsche Akkreditierungsstelle D-ZE-12005-01-01

Applicable documents: Assessment reports MOE 09-0326-06, MOE 09-0326-10, MOE 09-0326-13
Model validation report MOE 09-0326-07

Required components: PVI-PMU or equivalent component

Itzehoe - Germany, 2013-08-07

Dipl.-Ing Holger Becker
Deputy head of certification body

Dr. Rainer Zimmermann
Expert of certification body

**List of certificate revisions**

| Certificate No. | Date issued | Description / changes |
|---|---|---|
| MOE 09-0326-01 | 2010-12-22 | Initial revision, withdrawn 2012-04-18 |
| MOE 09-0326-11 | 2012-04-18 | Revision of section 3.7 (switching operations)<br>changed $k_u$, $k_f$ and $k_{i,max}$ values<br>withdrawn 2013-08-07 |
| MOE 09-0326-14 | 2013-08-07 | Section 1.3 (technical characteristics common to all types):<br>Added new software version, reference to M.O.E. certificate list<br><br>Section 3.1 (Active power output as a function of DC primary power):<br>Corrected nominal maximum reactive power value<br><br>Section 3.2 (active power output):<br>Changed specification of voltage dependence < 1.0 $U_N$<br><br>Section 3.5 (reactive power capability / PQ diagram):<br>Changed specification of voltage dependence < 1.0 $U_N$<br><br>Added section 3.13 (active power ramp rate control)<br><br>Revision of section 5.2 (configuration settings):<br>Added variable No.66 (maximum active current) |

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# 1. Specifications of generating unit


Figure 1: Image of the inverter (example, PVI-55.0-DE)

The certification is valid for the following Power One central inverter models:

| with low voltage isolation transformer (400 $V_{AC}$nominal output) | transformer-less (320 $V_{AC}$nominal output): | Nominal power (kW) |
|---|---|---|
| PVI-55.0-DE | PVI-55.0-TL-DE | 55 |
| PVI-110.0-DE | PVI-110.0-TL-DE | 110 |
| PVI-165.0-DE | PVI-165.0-TL-DE | 165 |
| PVI-220.0-DE | PVI-220.0-TL-DE | 220 |
| PVI-275.0-DE | PVI-275.0-TL-DE | 275 |
| PVI-330.0-DE | PVI-330.0-TL-DE | 330 |

## 1.1. Technical characteristics PVI-xxx.x-DE (with isolation transformer)

| | |
|---|---|
| AC nominal voltage: | 400 V |
| AC nominal frequency: | 50 Hz |
| AC nominal apparent power: | 62 / 124 / 186 / 248 / 310 / 372 kVA |
| AC nominal active power: | 55 / 110 / 165 / 220 / 275 / 330 kW |
| AC nominal current: | 81 / 162 / 243 / 324 / 405 / 486 A |
| Contribution to short circuit current: | 0.081 / 0.160 / 0.240 / 0.320 / 0.400 / 0.480 kA |

### 1.1.1. Specifications of the integrated isolation transformers

| Inverter model | Nominal voltages | Nominal power | Vector group | Idle current $i_0$ | Short circuit voltage $u_K$ | Idle loss | Short circuit loss |
|---|---|---|---|---|---|---|---|
| PVI-55.0-DE | 400V / 320.1V | 50 kVA | YNd11 | 2.77% | 3.35% | 300 W (0.60%) | 700 W (1.40%) |
| PVI-110.0-DE | 400V / 315.4V | 100 kVA | YNd11 | 2.42% | 3.40% | 500 W (0.50%) | 1500 W (1.50%) |
| PVI-165.0-DE | 400V / 315.6V | 200 kVA | YNd11 | 2.18% | 2.88% | 790 W (0.40%) | 2900 W (1.45%) |
| PVI-220.0-DE | | | | | | | |
| PVI-275.0-DE | 400V / 317.5V | 300 kVA | YNd11 | 2.19% | 3.82% | 1100 W (0.37%) | 3000 W (1.00%) |
| PVI-330.0-DE | | | | | | | |

Table 1: specifications of integrated isolation transformers for PVI-xxx.x-DE inverters

## 1.2. Technical characteristics PVI-xxx.0-TL-DE (transformer-less)

| | |
|---|---|
| AC nominal voltage: | 320 V |
| AC nominal frequency: | 50 Hz |
| AC nominal apparent power: | 62 / 124 / 186 / 248 / 310 / 372 kVA |
| AC nominal active power: | 55 / 110 / 165 / 220 / 275 / 330 kW |
| AC nominal current: | 101/ 202 / 303 / 404 / 505 / 606 A |
| Contribution to short circuit current: | 0.10 / 0.20 / 0.30 / 0.40 / 0.50 / 0.60 kA |

## 1.3. Technical characteristics common to all types

| | |
|---|---|
| DCMPP voltage: | 475 V – 950 V |
| Max. DC voltage: | 1000 V |
| Number of phases: | 3 |
| | |
| Firmwareversion DSP: | A.F.3.2 or E.F.1.1 |
| Firmware version Microprocessor: | B.F.0.9 or F.F.1.1 |

**Remark: Further permitted firmware versions will be listed in document QMV 3-13 01 on [http://www.moe-service.com/erstelltezertifikate.html](http://www.moe-service.com/erstelltezertifikate.html) .**

### 1.4. Technical characteristics AURORA PVI-PMU

Firmware version: Rev. 11

**Remark: Further permitted firmware versions will be listed in document QMV 3-13 01 on http://www.moe-service.com/erstelltezertifikate.html .**

## 2. Block diagrams of the generating unit

The Block diagrams show the main components of the inverters. Block diagrams are examples for the 110 kW inverter types (transformer-less and with 400V/320V isolation transformer). Depending on rated power, the unit contains 1, 2, 3, 4, 5, or 6 of the 55 kW inverter modules.

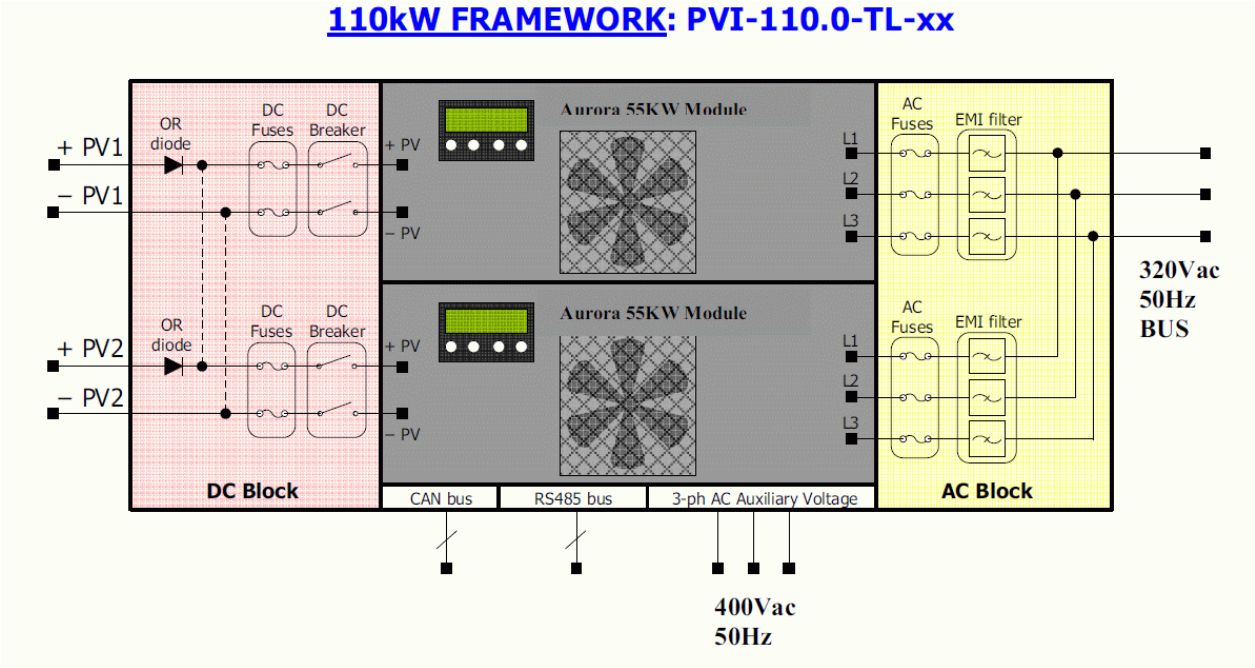


Figure 2: Block diagram of transformer-less version PVI-110.0-TL-DE

110 kW Framework: PVI-110.0-DE with Transformer

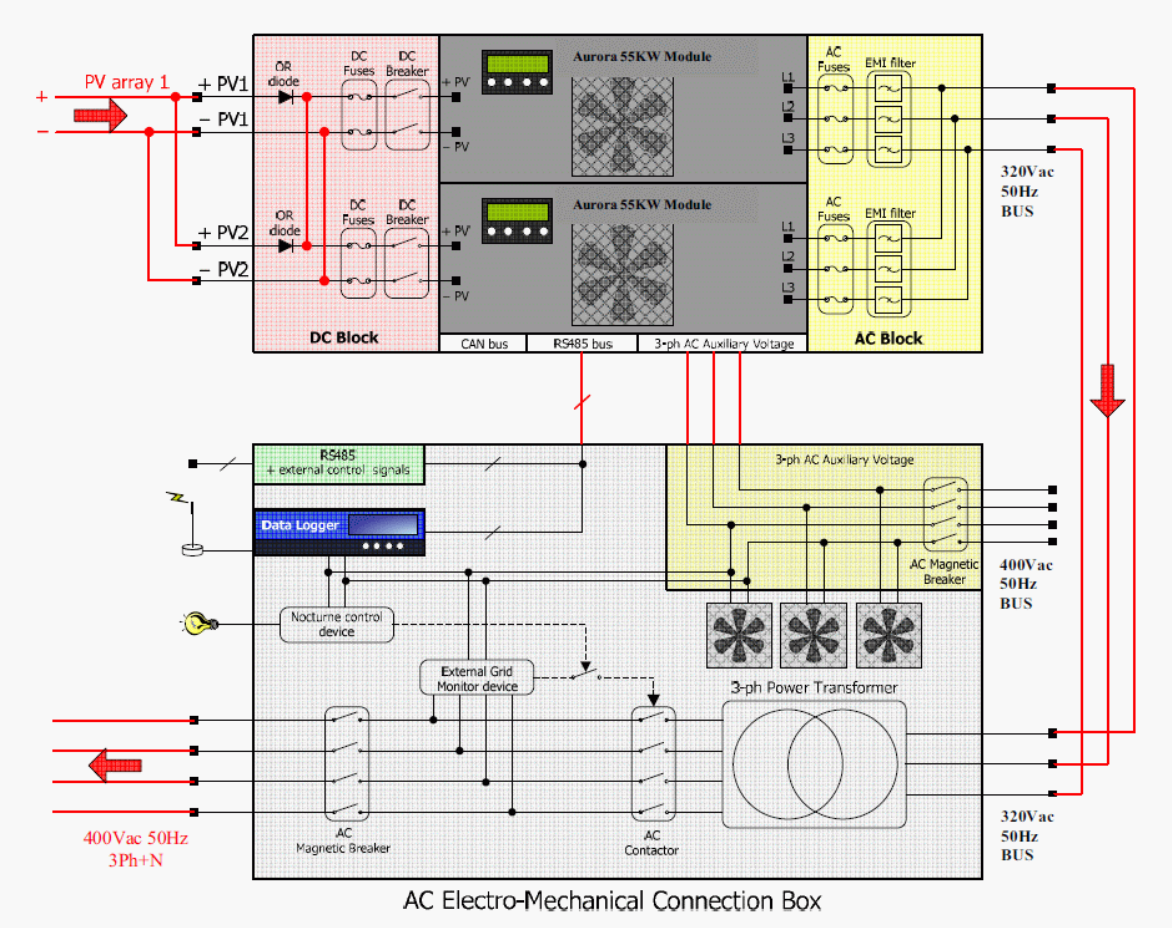


Figure 3: Block diagram of version with transformer PVI-110.0-DE

## 3. Results of thetype tests

All tests were performed according to FGW TR3 Rev.21 at the accredited test laboratory at Fraunhofer IWES, Kassel. Test results for PVI-55.0-TL-DE are documented in IWES test report 10-016, “Tests according to FGW TR3 Rev. 21 for PV-inverter PVI-Central-55 without transformer“, and the extract from the test report.

Additional tests concerning harmonics have been performed by IWES on the PVI-110.0-TL-DE unit and documented in test report 10-025 and the extract from the test report.

All tests were performed as laboratory tests with a DC source and partly with a grid simulator.

Adequacy of tests and conformity of test results was assessed by M.O.E. as documented in report /9/.

## 3.1. Active power output as a function of DC primary power

| DC power $P_{DC}$ (W) | AC output power $P_{AC}$ (W) | relative DC power $P_{DC}/P_N$ (%) | relative AC power $P_{AC}/P_N$ (%) |
|---|---|---|---|
| 3454 | 3144 | 6.3% | 5.7% |
| 9233 | 8677 | 16.8% | 15.8% |
| 14844 | 14185 | 27.0% | 25.8% |
| 20669 | 19690 | 37.6% | 35.8% |
| 26303 | 25187 | 47.8% | 45.8% |
| 32100 | 30672 | 58.4% | 55.8% |
| 37848 | 36137 | 68.8% | 65.7% |
| 43691 | 41544 | 79.4% | 75.5% |
| 49116 | 46911 | 89.3% | 85.3% |
| 54887 | 52296 | 99.8% | 95.1% |
| maximum | 55605 | - | 101.1% |

Table 2: active power output

Power values were measured for a PVI-55.0-TL-DE inverter. For other inverter types, the DC and output power has to be multiplied by the number of inverter modules. AC output values are $P_{600}$ values from the measurements (10min average values). $P_{600}$, $P_{60}$ and $P_{0.2}$ values (10min, 60s and 0.2s averages) are equal within ± 0.1% $P_N$.

Output power is independent from reactive power output over the entire reactive power range (nominally Q = ±26.6 kVAr per 55kW module at nominal voltage).

Note: The exact efficiency of the inverter and therefore output power for a given DC power may depend on DC voltage. The values given above were measured at $U_{DC}$ = 660 – 778 V.

## 3.2. Active power output for voltage deviations

The voltage dependence of maximum active power is specified as follows, based on a manufacturer declaration by Power-One.

Figure 4 shows the specified maximum active power output as a function of grid voltagein the range 0.9 $U_N \leq U \leq 1.1\ U_N$. Output power is always limited to nominal power $P_N$. Additionally, active current is limited to a maximum value which is defined by the setting of variable No. 66 ($I_{max,peak}$), which may be set in the range 140.3 A … 148.5 A. The variable value is given as a peak value, i.e. it must be divided by $\sqrt{2}$ to obtain the maximum active RMS current.

Mathematically, maximum active output power $P_{max}$ is given by the following formula:

$$P_{max} = min\begin{cases} P_N \\ I_{max,peak} \times U \times \sqrt{3}/\sqrt{2} \end{cases}$$

Where

$P_N$ = nominal active power (55.0 kW per module)
$I_{max,peak}$ = maximum active current given as peak value (defined by setting of variable No.66)
U = line-to-line RMS grid voltage.

In effect, this means that

1) for overvoltage conditions ($U_N \leq U \leq 1.1\ U_N$), maximum output power is constant at $P_N$.
2) for undervoltage conditions ($0.9\ U_N \leq U \leq U_N$), maximum output power is reduced proportionally to voltage, depending on the setting of variable No. 66.
   - At the minimum setting $I_{max,peak}$ = 140.3 A, the reduction of maximum active power starts at U = 1.0 $U_N$ and reaches 0.9 $P_N$ at U = 0.9 $U_N$.
   - At the maximum setting $I_{max,peak}$ = 148.5 A, the reduction of maximum active power starts at U = 0.945 $U_N$ and reaches 0.952 $P_N$ at U = 0.9 $U_N$ (see Figure 4).

Under partial load conditions, e.g. when active power output is limited by available input power to a value below $P_{max}$,output power is not influenced by the limit.

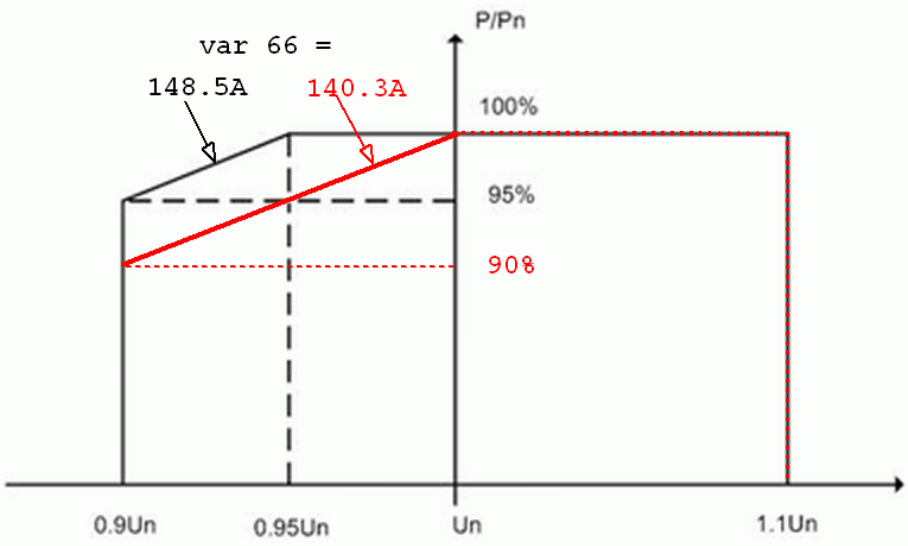


**Figure 4: Maximum active power output as a function of grid voltage, for parameter settings of variable No. 66 (maximum active current, $I_{max,peak}$) to 148.5 A and 140.3 A.**

## 3.3. Active power output for frequency deviations and over-frequency active power reduction

For frequency deviations within the range (47.5 Hz < f < 50.2 Hz), there is no dependence of active power output from grid frequency according to specification by Power One.

For frequency deviations above the nominal value, it was shown by measurement that the inverter behaves as required by the BDEW grid code /1/.

In grid frequency rises above f > 50.2 Hz, active power output is reduced with a gradient of (−40 ± 0.4) % $P_M$ /Hz based on initial power $P_M$. Output power is not raised again until the frequency falls below the threshold value 50.047 Hz.

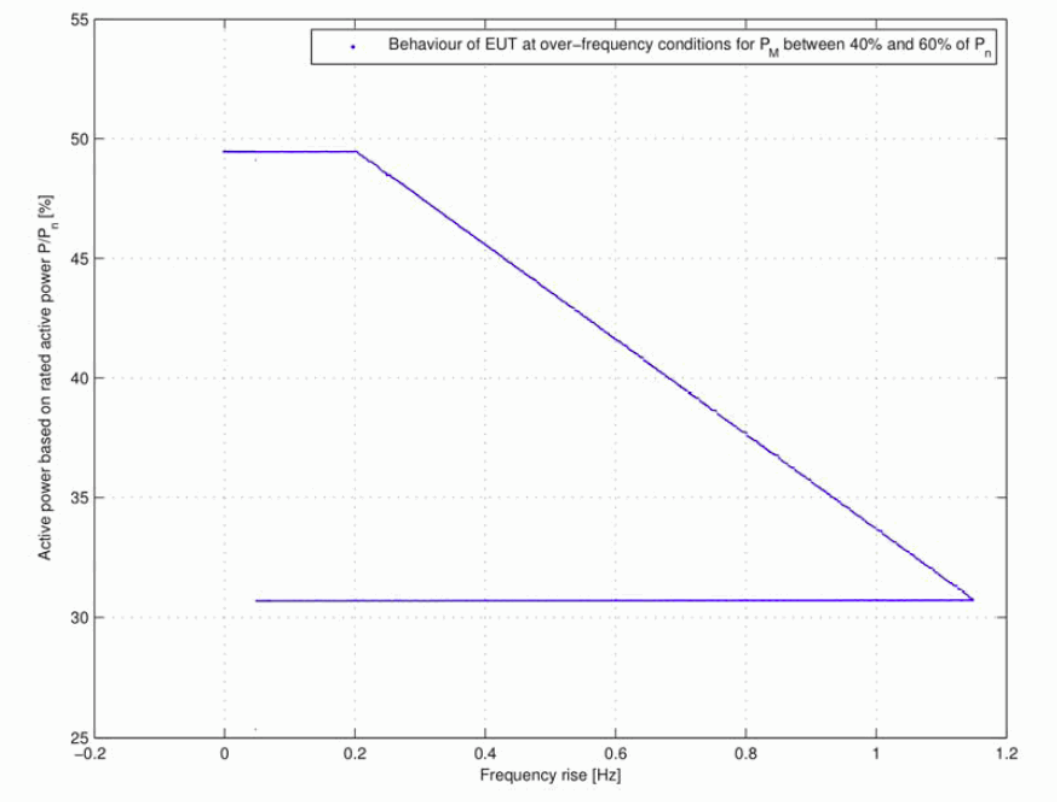


Figure 5: over-frequency active power reduction at initial power $P_M \approx 49\%\ P_N$

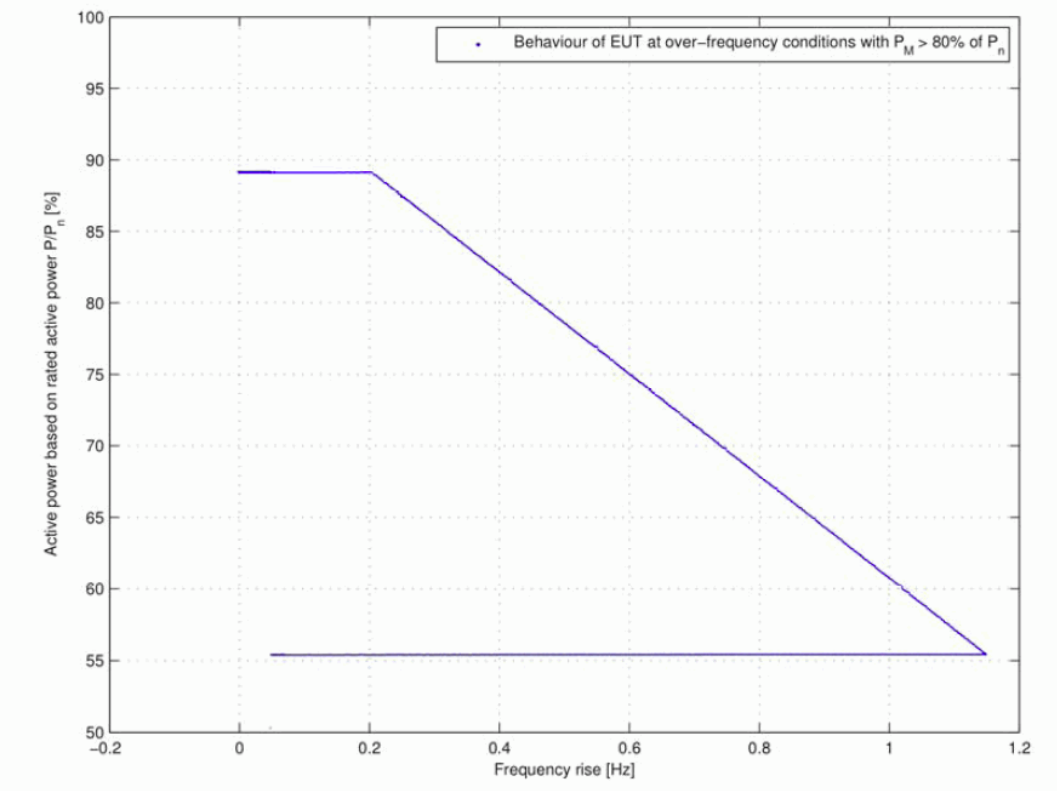


Figure 6: Over-frequency active power reduction at initial power PM ≈ 89% $P_N$

## 3.4. Active power reduction by set-point control

The Power One inverter provides four different interfaces for active power set-point control:

1. by four relay contacts (K1 to K4) with pre-set values 0, 30%, 60%, 100%using the AURORA PVI-PMU interface unit (with PMU switch position 0, 2 or 4)
2. by four relay contacts (K1 to K4) with 11 pre-set values using the AURORA PVI-PMU interface unit (with switch position 7)
3. by analog interface (4-20 mA) using the AURORA PVI-PMU interface unit (with switch positions 1,3,5 or 8)
4. by direct command via the RS485 interface, using the AURORA communication protocol (as documented in /7/), command code 151, with parameters Timeout = 10 min, Smooth = 0 and Optional = 0.

The AURORA PVI-PMU unit, if used, must be connected to all inverters of the generating plant through the RS485 bus.

If RS485 control is used, the controlling equipment must be programmed such that the time interval between the individual power reduction commands is always less than 10 minutes, unless the required value is $P/P_N$ = 100%. The use of timeout value 255, other addresses, other commands or other control modes than described above is not covered by the certification.

Test results for maximum deviations from set-points and reaction are shown in the following table. Values are measured at the 320V inverter terminals.

| Interface | Largest power deviation (positive) $\Delta P/P_N$ | Largest power deviation (negative) $\Delta P/P_N$ | Response time 100% to 30% $P_N$ | Reduction to 15% $P_N$ without disconnection |
|---|---|---|---|---|
| Relay K1-K4 | 0.4% | –3.4% | 2.6 s | successful |
| Analog 4-20mA | 2.6% | –3.4% | 4.2 s | successful |
| RS485 | none | –1.8% | 2.0 s | successful |

Table 3: Active power set-point control

The tests have demonstrated that for all three control methods, the accuracy of the power set-point is well within the permitted range of ± 10% $P_N$, and reaction times much shorter than the maximum allowed 60 seconds.

## 3.5. Reactive power capability (PQ diagram)

Figure 7 and Table 5 show maximum reactive power capability depending on active power level for the set-points Q=0 and Q = ± 27.1 kVAr (overexcited/underexcited, slightly outside the nominal maximum range) at nominal voltage. Values given are valid for the 320V terminals. In the case of the PVI-xxx.x-DE inverters, the effect of integrated transformer (see Table 1) on reactive power has to be considered additionally, e.g. by including a model of the transformer in the solar farm simulation. Absolute Q values are valid for the PVI-55.0(-TL)-DE inverters and have to be multiplied by the number of modules for the larger inverter types.

| **reactive power capability – absolute values PVI-55-TL-DE or PVI-55-DE on internal 320V terminals** | | | |
|---|---|---|---|
| power bin | maximum inductive (underexcited) | maximum capacitive (overexcited) | set-point Q = 0 |
| | Q (VAr) | | |
| 0%-10% | -27450 | 26121 | -479 |
| 10%-20% | -27270 | 26294 | -286 |
| 20%-30% | -27061 | 26522 | -50 |
| 30%-40% | -26816 | 26762 | 154 |
| 40%-50% | -26584 | 26962 | 363 |
| 50%-60% | -26386 | 27183 | 583 |
| 60%-70% | -26148 | 27425 | 803 |
| 70%-80% | -25923 | 27629 | 1018 |
| 80%-90% | -25724 | 27858 | 1227 |
| 90%-100% | -25501 | 28070 | 1436 |

Table 4: reactive power capability – absolute values (PVI-55-TL-DE or PVI-55-DE on internal 320V terminals)

| reactive power capability – PVI-xxx.x-TL-DE or PVI-xxx.x-DE on internal 320V terminals | | | | | | |
|---|---|---|---|---|---|---|
| power bin | maximum inductive (underexcited) | maximum capacitive (overexcited) | set-point Q = 0 | maximum inductive (underexcited) | maximum capacitive (overexcited) | set-point Q = 0 |
| | $Q/P_N$ | | | cos φ | | |
| 0%-10% | -49.9% | 47.5% | -0.9% | 0.895 | 0.903 | 1.000 |
| 10%-20% | -49.6% | 47.8% | -0.5% | 0.896 | 0.902 | 1.000 |
| 20%-30% | -49.2% | 48.2% | -0.1% | 0.897 | 0.901 | 1.000 |
| 30%-40% | -48.8% | 48.7% | 0.3% | 0.899 | 0.899 | 1.000 |
| 40%-50% | -48.3% | 49.0% | 0.7% | 0.900 | 0.898 | 1.000 |
| 50%-60% | -48.0% | 49.4% | 1.1% | 0.902 | 0.896 | 1.000 |
| 60%-70% | -47.5% | 49.9% | 1.5% | 0.903 | 0.895 | 1.000 |
| 70%-80% | -47.1% | 50.2% | 1.9% | 0.905 | 0.894 | 1.000 |
| 80%-90% | -46.8% | 50.7% | 2.2% | 0.906 | 0.892 | 1.000 |
| 90%-100% | -46.4% | 51.0% | 2.6% | 0.907 | 0.891 | 1.000 |

Table 5: reactive power capability – relative values and cos φ

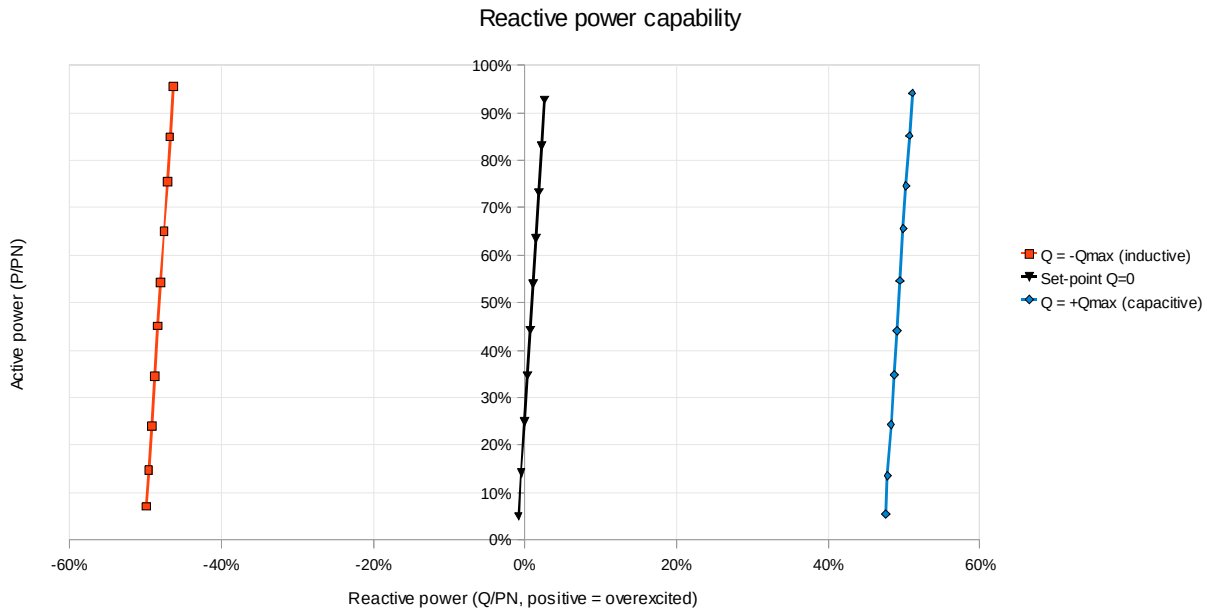


Figure 7: reactive power capability (PQ diagram) for PVI-xxx.x-TL-DE and PVI-xxx.x-DE on internal 320V terminals

### 3.5.1. Voltage dependence of reactive power capability

The voltage dependence of reactive power capability is specified as follows, based on a manufacturer declaration by Power-One.

Maximum reactive power capability $Q_{max}$(valid symmetrically for both overexcited and underexcited conditions) is proportional to maximum active power, i.e. $Q_{max} = 0.4836\ P_{max}$ (with $P_{max}$ as defined in section 3.2).

In effect, this means that

1) At or above nominal voltage ($U_N \leq U \leq 1.1\ U_N$), maximum reactive power is constant at $Q_{max} = 0.4836\ P_N$.
2) For undervoltage conditions ($0.9\ U_N \leq U \leq U_N$), maximum reactive power is reduced proportionally to voltage, depending on the setting of variable No. 66 (maximum active current).
    - At the minimum setting $I_{max,peak} = 140.3$ A, the reduction of maximum reactive power starts at $U = 1.0\ U_N$ and reaches $0.4353\ P_N = 0.9\ Q_N$ at $U = 0.9\ U_N$.
    - For the maximum setting $I_{max,peak} = 148.5$ A, the reduction of maximum active power starts at $U = 0.945\ U_N$ and reaches $0.4604\ P_N = 0.952\ Q_N$ at $U = 0.9\ U_N$ (see Figure 8).

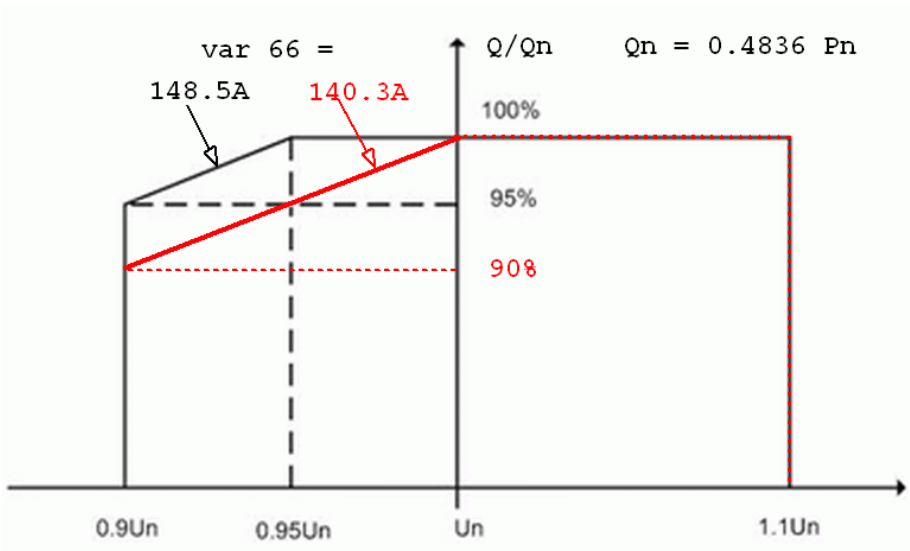


**Figure 8: Reactive power capability as a function of grid voltage, for parameter settings of variable No. 66 (maximum active current, $I_{max,peak}$) to 148.5 A and 140.3 A.**

## 3.6. Reactive power set-point control

Three different methods for reactive power set-point control are covered by the certification:

1. by analog interface 4-20 mA using the AURORA PVI-PMU interface unit, connected to the inverter via RS485 (with PMU switch positions 2,3,4,5,7 or 8)
2. by direct command via the RS485 interface, using the AURORA communication protocol command 152 with mode 1 (fixed cos φ based on $P_N$, equivalent to fixed Q, as documented in /7/), with parameters Timeout = 10 min, Smooth = 0 and Pth/Reserved = 0 and Address = 250 (broadcast mode)
3. by direct command via the RS485 interface, using the AURORA communication protocol command 152 with mode 4 (fixed cos φ, as documented in /7/), with parameters Timeout = 10 min, Smooth = 0 and Pth/Reserved = 0 and Address = 250 (broadcast mode).

The AURORA PVI-PMU unit, if used, must be connected to all inverters of the generating plant through the RS485 bus.

If RS485 control is used, the controlling equipment must be programmed such that the time interval between the individual active and reactive power control commands is always less than 10 minutes, unless the set-point value is cos φ = 1 or Q = 0. The use of timeout value 255, other addresses, other commands or other control modes than described above is not covered by the certification.

### 3.6.1. Maximum deviation of reactive power values

| Reactive power set-point $Q/P_N$ | Measured reactive power $Q/P_N$ | Deviation $\Delta Q/P_N$ |
|---|---|---|
| –48.35% | –47.06% | 1.29% |
| 2.37% | 0.21% | –2.16% |
| 48.43% | 48.25% | –0.18% |

**Table 6: Tolerance of reactive power set-point control by analog interface for all PVI-xxx.x-TL-DE inverters, or PVI-xxx.x-DE on internal 320V terminals**

| Reactive power set-point $Q/P_N$ | Measured reactive power $Q/P_N$ | Deviation $\Delta Q/P_N$ |
|---|---|---|
| –48.15% | –46.43% | 1.72% |
| 0.00% | 0.94% | 0.94% |
| 48.15% | 49.62% | 1.47% |

**Table 7: Tolerance of reactive power set-point control by RS485 interface (fixed Q mode) for all PVI-xxx.x-TL-DE inverters, or PVI-xxx.x-DE on internal 320V terminals**

| cos φ set-point | Measured cos φ | Deviation Δ(cos φ) | Reactive power set-point $Q/P_N$ | Measured reactive power $Q/P_N$ | Deviation $\Delta Q/P_N$ |
|---|---|---|---|---|---|
| 0.901 (underexcited) | 0.914 | –0.013[1)] | –24.07% | –22.19% | 1.88% |
| 1.000 | 0.998 | 0.002 | 0.00% | 3.17% | 3.17% |
| 0.901 (overexcited) | 0.880 | 0.021[1)] | 24.07% | 26.99% | 2.91% |

**Table 8: Tolerance of reactive power set-point control by RS485 interface (fixed cos φ mode) for all PVI-xxx.x-TL-DE inverters, or PVI-xxx.x-DE on internal 320V terminals**

Remarks:

1) For set-point control by cos φ values via RS458, the deviation for these measurements on the 320V level formally exceeds the tolerance permitted by FGW TR8 (± 0.005). However, the behavior of reactive power in a solar farm installation generally needs to be assessed at the PCC, where it will be influenced by transformers and cables, usually towards more underexcited values. If direct set-point control without regulation is used, this may have a compensating effect on the deviation. If a regulator for reactive power is used on the farm level, the observed deviation is irrelevant, as it will be compensated by the regulator.

All deviations of reactive power ΔQ are within the permitted tolerance ± 0.05 $P_N$.

### 3.6.2. Reaction to reactive power set-point changes

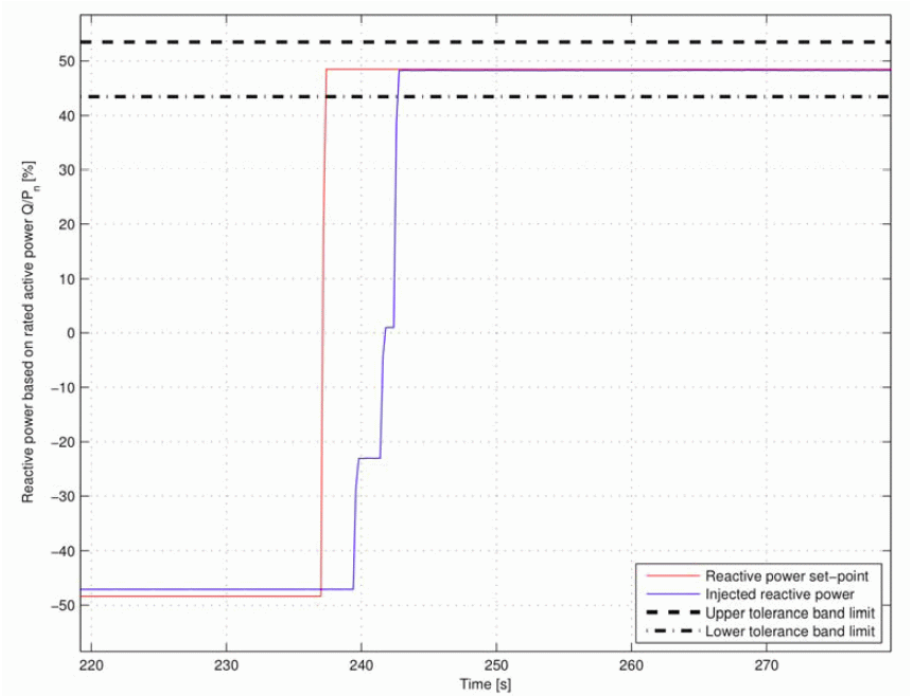


Figure 9: reaction to Q set-point change from $-Q_{max}$ to $+Q_{max}$ with analog interface

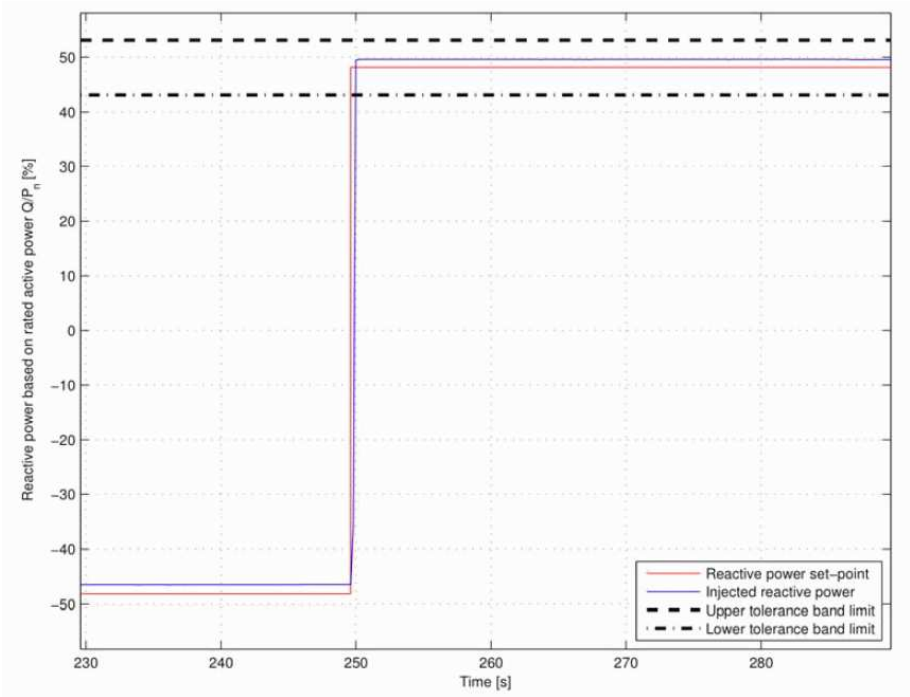


Figure 10: Reaction to Q set-point change from $-Q_{max}$ to $+Q_{max}$ with RS485 interface in fixed Q mode

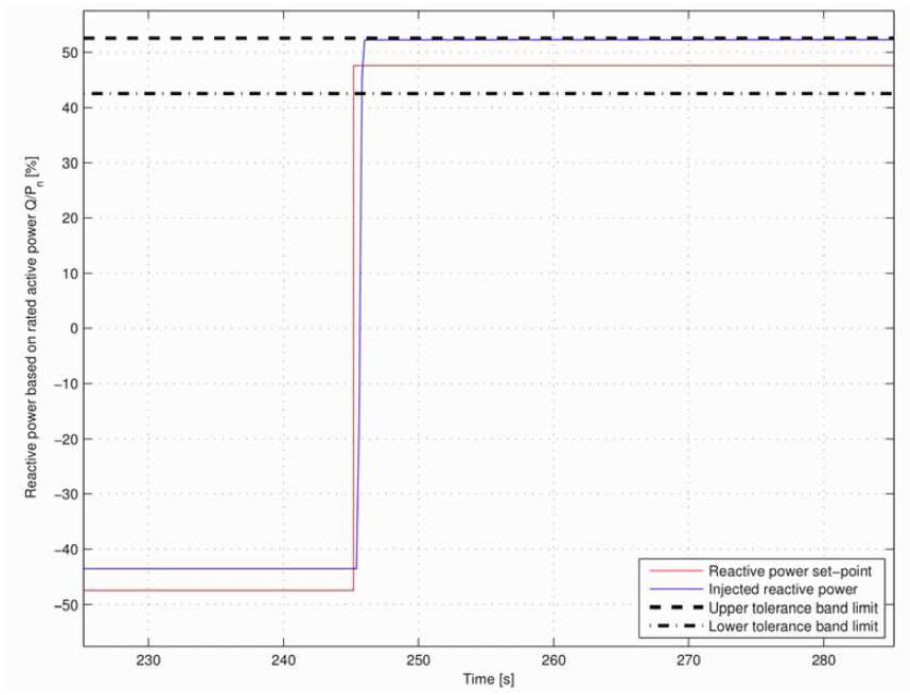


Figure 11: Reaction to Q set-point change from $-Q_{max}$ to $+Q_{max}$ with RS485 interface in fixed cos phi mode

Maximum response times for a Q set-point step over the full range are shown in the table. All results are well below the limit of 1 minute.

| Q-step response times | $0 \rightarrow -Q_{max}$ | $-Q_{max} \rightarrow +Q_{max}$ | $+Q_{max} \rightarrow 0$ |
|---|---|---|---|
| Analog Interface | 2.6s | 5.6s | 3.4s |
| RS485 (fixed Q mode) | 0.4s | 0.4s | 0.2s |
| RS485 (fixed cos φ mode),at 50% $P_N$ | 0.6s | 1.0s | 1.0s |
| RS485 (fixed cos φ mode),at 100% $P_N$ | 0.8s | 0.6s | 0.6s |

Table 9: reaction times for reactive power set-point control for all PVI-xxx.x-TL-DE inverters

## 3.7. Power quality – continuous flicker and switching operations

| Network impedance angle $\psi_k$ | 30° | 50° | 70° | 85° |
|---|---|---|---|---|
| | | | | |
| **continuous fluctuations** | | | | |
| Flicker coefficient $c(\psi_k)$ based on current flicker | 0.4 | 0.33 | 0.22 | 0.16 |
| | | | | |
| **switch-on at 10% of rated active power** | | | | |
| Flicker step factor $k_f(\psi_k)$ | 0.12 | 0.10 | 0.06 | 0.05 |
| Voltage change factor $k_u(\psi_k)$ | 0.12 | 0.10 | 0.06 | 0.05 |
| Maximal current step factor $k_{i.max}$ | 0.15 | | | |
| Maximal number of switching operations. $N_{10}$ | 5 | | | |
| Maximal number of switching operations. $N_{120}$ | 20 | | | |
| | | | | |
| **switch-on at 100% of rated active power** | | | | |
| Flicker step factor $k_f(\psi_k)$ | 0.91 | 0.70 | 0.41 | 0.16 |
| Voltage change factor $k_u(\psi_k)$ | 0.92 | 0.71 | 0.41 | 0.16 |
| Maximal current step factor $k_{i.max}$ | 1.02 | | | |
| Maximal number of switching operations, $N_{10}$ | 5 | | | |
| Maximal number of switching operations, $N_{120}$ | 20 | | | |
| | | | | |
| **switch-off at 100% of rated active power** | | | | |
| Flicker step factor $k_f(\psi_k)$ | 0.92 | 0.84 | 0.72 | 0.60 |
| Voltage change factor $k_u(\psi_k)$ | 0.92 | 0.84 | 0.72 | 0.60 |
| Maximal current step factor $k_{i.max}$ | 1.02 | | | |
| Maximal number of switching operations, $N_{10}$ | 5 | | | |
| Maximal number of switching operations, $N_{120}$ | 20 | | | |
| | | | | |
| **worst case of all switching operations** | | | | |
| Maximal current step factor $k_{i.max}$ | 1.02 | | | |

**Table 10: continuous flicker and switching operation data for all inverter variants. Valid on the 320V or 400V terminals.**

Remark: The Flicker coefficient c and the values in connection of switching events are relative values based on rated power and are valid for all types of the PVI family which are covered by this certificate.

## 3.8. Power quality – harmonics, interharmonics and higher frequency components

| Harmonics – PVI-55.0-TL-DE and PVI-55.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1 | 6.90 | 18.27 | 28.77 | 39.22 | 49.66 | 59.91 | 69.24 | 79.34 | 89.35 | 98.47 | 98.47 |
| 2 | 0.26 | 0.30 | 0.29 | 0.29 | 0.29 | 0.28 | 0.30 | 0.31 | 0.33 | 0.34 | 0.34 |
| 3 | 1.36 | 1.36 | 1.44 | 1.48 | 1.49 | 1.49 | 1.48 | 1.50 | 1.52 | 1.49 | 1.52 |
| 4 | 0.08 | 0.12 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 |
| 5 | 1.90 | 1.88 | 2.17 | 2.58 | 2.82 | 3.23 | 3.42 | 3.59 | 3.56 | 3.65 | 3.65 |
| 6 | 0.07 | 0.10 | 0.12 | 0.13 | 0.13 | 0.15 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 |
| 7 | 1.07 | 1.15 | 1.59 | 1.70 | 1.56 | 1.46 | 1.27 | 1.11 | 0.97 | 0.81 | 1.70 |
| 8 | 0.03 | 0.06 | 0.06 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 |
| 9 | 0.18 | 0.15 | 0.13 | 0.17 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 |
| 10 | 0.02 | 0.06 | 0.07 | 0.05 | 0.05 | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.07 |
| 11 | 0.23 | 0.30 | 0.57 | 0.51 | 0.39 | 0.27 | 0.35 | 0.42 | 0.50 | 0.61 | 0.61 |
| 12 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 |
| 13 | 0.31 | 0.43 | 0.59 | 0.52 | 0.43 | 0.33 | 0.43 | 0.49 | 0.50 | 0.52 | 0.59 |
| 14 | 0.02 | 0.04 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.05 |
| 15 | 0.07 | 0.06 | 0.05 | 0.04 | 0.06 | 0.04 | 0.04 | 0.06 | 0.07 | 0.07 | 0.07 |
| 16 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 |
| 17 | 0.35 | 0.39 | 0.39 | 0.49 | 0.43 | 0.35 | 0.36 | 0.40 | 0.43 | 0.47 | 0.49 |
| 18 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 19 | 0.20 | 0.18 | 0.20 | 0.22 | 0.26 | 0.30 | 0.22 | 0.21 | 0.26 | 0.32 | 0.32 |
| 20 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 |
| 21 | 0.04 | 0.05 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 | 0.05 |
| 22 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 23 | 0.10 | 0.24 | 0.18 | 0.20 | 0.19 | 0.19 | 0.16 | 0.16 | 0.17 | 0.19 | 0.24 |
| 24 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25 | 0.07 | 0.12 | 0.12 | 0.19 | 0.17 | 0.13 | 0.12 | 0.14 | 0.13 | 0.14 | 0.19 |
| 26 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| 27 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 28 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 29 | 0.03 | 0.05 | 0.06 | 0.06 | 0.06 | 0.05 | 0.08 | 0.08 | 0.07 | 0.07 | 0.08 |
| 30 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31 | 0.04 | 0.05 | 0.04 | 0.02 | 0.03 | 0.06 | 0.06 | 0.06 | 0.05 | 0.04 | 0.06 |
| 32 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 33 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 34 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 35 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 36 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37 | 0.04 | 0.05 | 0.05 | 0.05 | 0.06 | 0.08 | 0.08 | 0.09 | 0.08 | 0.09 | 0.09 |
| 38 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.04 | 0.04 |
| 39 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.04 | 0.03 | 0.07 | 0.07 |
| 40 | 0.01 | 0.01 | 0.03 | 0.04 | 0.03 | 0.03 | 0.07 | 0.08 | 0.02 | 0.02 | 0.08 |
| 41 | 0.03 | 0.08 | 0.10 | 0.18 | 0.22 | 0.18 | 0.17 | 0.17 | 0.15 | 0.11 | 0.22 |
| 42 | 0.01 | 0.02 | 0.02 | 0.08 | 0.02 | 0.02 | 0.08 | 0.10 | 0.02 | 0.06 | 0.10 |
| 43 | 0.07 | 0.11 | 0.05 | 0.14 | 0.19 | 0.15 | 0.15 | 0.15 | 0.12 | 0.10 | 0.19 |
| 44 | 0.02 | 0.02 | 0.02 | 0.11 | 0.03 | 0.04 | 0.03 | 0.03 | 0.02 | 0.07 | 0.11 |
| 45 | 0.02 | 0.12 | 0.04 | 0.04 | 0.04 | 0.03 | 0.05 | 0.07 | 0.03 | 0.04 | 0.12 |
| 46 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.04 | 0.04 | 0.04 | 0.02 | 0.02 | 0.04 |
| 47 | 0.09 | 0.07 | 0.08 | 0.06 | 0.07 | 0.08 | 0.09 | 0.08 | 0.08 | 0.06 | 0.09 |
| 48 | 0.01 | 0.02 | 0.02 | 0.04 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.04 |
| 49 | 0.11 | 0.17 | 0.10 | 0.09 | 0.10 | 0.07 | 0.09 | 0.09 | 0.10 | 0.12 | 0.17 |
| 50 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.04 | 0.04 |
| THC | 2.66 | 2.73 | 3.22 | 3.59 | 3.68 | 3.93 | 4.04 | 4.16 | 4.13 | 4.18 | 4.48 |

Table 11: Harmonics – PVI-55.0-TL-DE and PVI-55.0-DE

| **Interharmonics – PVI-55.0-TL-DE and PVI-55.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1.5 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 2.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 5.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 |
| 6.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.04 |
| 7.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 |
| 8.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 9.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| 10.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 |
| 11.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 |
| 12.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 |
| 13.5 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 14.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 |
| 15.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 16.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 17.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 18.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 19.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 20.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 21.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 22.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 23.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 24.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 25.5 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 |
| 26.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 27.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 30.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 32.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 33.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 35.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 36.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 |
| 37.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 |
| 38.5 | 0.01 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.05 | 0.05 | 0.05 | 0.05 |
| 39.5 | 0.01 | 0.02 | 0.02 | 0.03 | 0.02 | 0.04 | 0.04 | 0.09 | 0.10 | 0.09 | 0.10 |

**Table 12: Interharmonics – PVI-55.0-TL-DE and PVI-55.0-DE**

| Higher frequency components – PVI-55.0-TL-DE and PVI-55.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| f (kHz) | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 2.1 | 0.08 | 0.14 | 0.14 | 0.23 | 0.28 | 0.27 | 0.28 | 0.28 | 0.24 | 0.20 | 0.28 |
| 2.3 | 0.10 | 0.14 | 0.17 | 0.17 | 0.12 | 0.13 | 0.13 | 0.14 | 0.14 | 0.13 | 0.17 |
| 2.5 | 0.13 | 0.25 | 0.20 | 0.20 | 0.21 | 0.21 | 0.20 | 0.21 | 0.22 | 0.22 | 0.25 |
| 2.7 | 0.23 | 0.31 | 0.29 | 0.27 | 0.31 | 0.31 | 0.31 | 0.31 | 0.31 | 0.33 | 0.33 |
| 2.9 | 0.22 | 0.29 | 0.34 | 0.35 | 0.35 | 0.36 | 0.36 | 0.37 | 0.37 | 0.38 | 0.38 |
| 3.1 | 0.16 | 0.27 | 0.33 | 0.36 | 0.35 | 0.28 | 0.29 | 0.30 | 0.28 | 0.31 | 0.36 |
| 3.3 | 0.10 | 0.19 | 0.25 | 0.17 | 0.20 | 0.15 | 0.12 | 0.13 | 0.15 | 0.17 | 0.25 |
| 3.5 | 0.05 | 0.07 | 0.08 | 0.08 | 0.07 | 0.06 | 0.06 | 0.06 | 0.07 | 0.07 | 0.08 |
| 3.7 | 0.04 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 |
| 3.9 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.07 |
| 4.1 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.07 | 0.06 | 0.07 |
| 4.3 | 0.02 | 0.04 | 0.04 | 0.05 | 0.05 | 0.04 | 0.03 | 0.02 | 0.02 | 0.03 | 0.05 |
| 4.5 | 0.02 | 0.03 | 0.04 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 |
| 4.7 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 4.9 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.3 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.9 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.1 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.3 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.7 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.9 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.1 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.3 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.9 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 8.1 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 8.3 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 8.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 8.7 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 8.9 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |

**Table 13: Higher frequency components – PVI-55.0-TL-DE and PVI-55.0-DE**

| **Harmonics – PVI-110.0-TL-DE and PVI-110.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1 | 6.90 | 18.27 | 28.77 | 39.22 | 49.66 | 59.91 | 69.24 | 79.34 | 89.35 | 98.47 | 98.47 |
| 2 | 0.18 | 0.21 | 0.20 | 0.21 | 0.20 | 0.20 | 0.21 | 0.22 | 0.23 | 0.24 | 0.24 |
| 3 | 0.96 | 0.96 | 1.02 | 1.04 | 1.06 | 1.05 | 1.05 | 1.06 | 1.08 | 1.05 | 1.08 |
| 4 | 0.08 | 0.12 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 |
| 5 | 1.34 | 1.33 | 1.54 | 1.82 | 1.99 | 2.28 | 2.42 | 2.54 | 2.52 | 2.58 | 2.58 |
| 6 | 0.05 | 0.07 | 0.09 | 0.09 | 0.09 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 |
| 7 | 0.76 | 0.81 | 1.12 | 1.20 | 1.10 | 1.03 | 0.90 | 0.79 | 0.69 | 0.57 | 1.20 |
| 8 | 0.02 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 9 | 0.18 | 0.15 | 0.13 | 0.17 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 |
| 10 | 0.01 | 0.04 | 0.05 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.05 |
| 11 | 0.16 | 0.21 | 0.40 | 0.36 | 0.27 | 0.19 | 0.25 | 0.30 | 0.35 | 0.43 | 0.43 |
| 12 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 |
| 13 | 0.22 | 0.30 | 0.41 | 0.36 | 0.30 | 0.23 | 0.31 | 0.35 | 0.35 | 0.37 | 0.41 |
| 14 | 0.01 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 15 | 0.05 | 0.04 | 0.04 | 0.03 | 0.04 | 0.03 | 0.02 | 0.04 | 0.05 | 0.05 | 0.05 |
| 16 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 17 | 0.25 | 0.28 | 0.28 | 0.35 | 0.30 | 0.25 | 0.26 | 0.28 | 0.30 | 0.33 | 0.35 |
| 18 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 19 | 0.14 | 0.13 | 0.14 | 0.16 | 0.19 | 0.21 | 0.16 | 0.15 | 0.18 | 0.23 | 0.23 |
| 20 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 |
| 21 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 22 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 23 | 0.07 | 0.17 | 0.12 | 0.14 | 0.14 | 0.13 | 0.11 | 0.11 | 0.12 | 0.14 | 0.17 |
| 24 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25 | 0.05 | 0.08 | 0.08 | 0.14 | 0.12 | 0.09 | 0.09 | 0.10 | 0.09 | 0.10 | 0.14 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 |
| 28 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29 | 0.02 | 0.03 | 0.04 | 0.05 | 0.04 | 0.03 | 0.05 | 0.06 | 0.05 | 0.05 | 0.06 |
| 30 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 |
| 31 | 0.03 | 0.03 | 0.03 | 0.01 | 0.02 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 |
| 37 | 0.03 | 0.04 | 0.04 | 0.03 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 38 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.03 | 0.03 |
| 39 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.05 | 0.05 |
| 40 | 0.01 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.05 | 0.06 | 0.02 | 0.01 | 0.06 |
| 41 | 0.02 | 0.06 | 0.07 | 0.13 | 0.15 | 0.13 | 0.12 | 0.12 | 0.10 | 0.08 | 0.15 |
| 42 | 0.01 | 0.01 | 0.01 | 0.06 | 0.02 | 0.01 | 0.06 | 0.07 | 0.02 | 0.04 | 0.07 |
| 43 | 0.05 | 0.08 | 0.03 | 0.10 | 0.13 | 0.11 | 0.11 | 0.11 | 0.08 | 0.07 | 0.13 |
| 44 | 0.01 | 0.01 | 0.02 | 0.07 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.05 | 0.07 |
| 45 | 0.02 | 0.08 | 0.03 | 0.03 | 0.03 | 0.02 | 0.04 | 0.05 | 0.02 | 0.03 | 0.08 |
| 46 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.01 | 0.02 | 0.03 |
| 47 | 0.06 | 0.05 | 0.05 | 0.04 | 0.05 | 0.06 | 0.06 | 0.06 | 0.05 | 0.04 | 0.06 |
| 48 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 |
| 49 | 0.08 | 0.12 | 0.07 | 0.06 | 0.07 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.12 |
| 50 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| THC | 1.88 | 1.93 | 2.28 | 2.54 | 2.60 | 2.78 | 2.86 | 2.95 | 2.92 | 2.96 | 3.17 |

**Table 14: Harmonics – PVI-110.0-TL-DE and PVI-110.0-DE**

| **Interharmonics – PVI-110.0-TL-DE and PVI-110.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1.5 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 2.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 5.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 6.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 7.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 8.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 9.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 10.5 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 |
| 11.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 |
| 12.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 13.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 14.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 15.5 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 16.5 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 17.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 18.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 19.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 20.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 23.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 26.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 30.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 32.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 33.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 36.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 37.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| 38.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 | 0.03 | 0.04 | 0.04 |
| 39.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.03 | 0.07 | 0.07 | 0.07 | 0.07 |

**Table 15: Interharmonics – PVI-110.0-TL-DE and PVI-110.0-DE**

| Higher frequency components – PVI-110.0-TL-DE and PVI-110.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| f (kHz) | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 2.1 | 0.05 | 0.10 | 0.10 | 0.16 | 0.20 | 0.19 | 0.20 | 0.20 | 0.17 | 0.14 | 0.20 |
| 2.3 | 0.07 | 0.10 | 0.12 | 0.12 | 0.09 | 0.09 | 0.09 | 0.10 | 0.10 | 0.09 | 0.12 |
| 2.5 | 0.09 | 0.17 | 0.14 | 0.14 | 0.15 | 0.14 | 0.14 | 0.15 | 0.15 | 0.16 | 0.17 |
| 2.7 | 0.16 | 0.22 | 0.20 | 0.19 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.23 | 0.23 |
| 2.9 | 0.16 | 0.21 | 0.24 | 0.25 | 0.25 | 0.25 | 0.25 | 0.26 | 0.26 | 0.27 | 0.27 |
| 3.1 | 0.11 | 0.19 | 0.23 | 0.25 | 0.25 | 0.20 | 0.21 | 0.21 | 0.20 | 0.22 | 0.25 |
| 3.3 | 0.07 | 0.14 | 0.18 | 0.12 | 0.14 | 0.10 | 0.08 | 0.09 | 0.11 | 0.12 | 0.18 |
| 3.5 | 0.03 | 0.05 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 |
| 3.7 | 0.04 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 |
| 3.9 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 |
| 4.1 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.05 | 0.04 | 0.05 |
| 4.3 | 0.01 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 4.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 4.9 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.1 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.3 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.7 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 |
| 6.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 6.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 16: Higher frequency components – PVI-110.0-TL-DE and PVI-110.0-DE**

| Harmonics – PVI-165.0-TL-DE and PVI-165.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1 | 6.90 | 18.27 | 28.77 | 39.22 | 49.66 | 59.91 | 69.24 | 79.34 | 89.35 | 98.47 | 98.47 |
| 2 | 0.15 | 0.17 | 0.17 | 0.17 | 0.17 | 0.16 | 0.17 | 0.18 | 0.19 | 0.20 | 0.20 |
| 3 | 0.78 | 0.79 | 0.83 | 0.85 | 0.86 | 0.86 | 0.85 | 0.86 | 0.88 | 0.86 | 0.88 |
| 4 | 0.08 | 0.12 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 |
| 5 | 1.10 | 1.08 | 1.25 | 1.49 | 1.63 | 1.86 | 1.98 | 2.07 | 2.06 | 2.11 | 2.11 |
| 6 | 0.04 | 0.06 | 0.07 | 0.08 | 0.08 | 0.09 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 |
| 7 | 0.62 | 0.66 | 0.92 | 0.98 | 0.90 | 0.84 | 0.73 | 0.64 | 0.56 | 0.47 | 0.98 |
| 8 | 0.01 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| 9 | 0.18 | 0.15 | 0.13 | 0.17 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 |
| 10 | 0.01 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 |
| 11 | 0.13 | 0.17 | 0.33 | 0.30 | 0.22 | 0.16 | 0.20 | 0.24 | 0.29 | 0.35 | 0.35 |
| 12 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 |
| 13 | 0.18 | 0.25 | 0.34 | 0.30 | 0.25 | 0.19 | 0.25 | 0.28 | 0.29 | 0.30 | 0.34 |
| 14 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 15 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.04 |
| 16 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 17 | 0.20 | 0.23 | 0.23 | 0.28 | 0.25 | 0.20 | 0.21 | 0.23 | 0.25 | 0.27 | 0.28 |
| 18 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19 | 0.12 | 0.10 | 0.12 | 0.13 | 0.15 | 0.17 | 0.13 | 0.12 | 0.15 | 0.18 | 0.18 |
| 20 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| 21 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.03 |
| 22 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 23 | 0.06 | 0.14 | 0.10 | 0.12 | 0.11 | 0.11 | 0.09 | 0.09 | 0.10 | 0.11 | 0.14 |
| 24 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25 | 0.04 | 0.07 | 0.07 | 0.11 | 0.10 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.11 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29 | 0.02 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 |
| 30 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 31 | 0.02 | 0.03 | 0.02 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 37 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.05 |
| 38 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.03 | 0.02 | 0.04 | 0.04 |
| 40 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.05 | 0.01 | 0.01 | 0.05 |
| 41 | 0.02 | 0.05 | 0.06 | 0.11 | 0.12 | 0.10 | 0.10 | 0.10 | 0.08 | 0.07 | 0.12 |
| 42 | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.01 | 0.05 | 0.06 | 0.01 | 0.03 | 0.06 |
| 43 | 0.04 | 0.06 | 0.03 | 0.08 | 0.11 | 0.09 | 0.09 | 0.09 | 0.07 | 0.06 | 0.11 |
| 44 | 0.01 | 0.01 | 0.01 | 0.06 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.04 | 0.06 |
| 45 | 0.01 | 0.07 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.02 | 0.02 | 0.07 |
| 46 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 47 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.04 | 0.03 | 0.05 |
| 48 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 49 | 0.06 | 0.10 | 0.06 | 0.05 | 0.06 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.10 |
| 50 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| THC | 1.54 | 1.58 | 1.87 | 2.08 | 2.13 | 2.27 | 2.34 | 2.41 | 2.39 | 2.42 | 2.59 |

**Table 17: Harmonics – PVI-165.0-TL-DE and PVI-165.0-DE**

| **Interharmonics – PVI-165.0-TL-DE and PVI-165.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1.5 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 2.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 5.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 6.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 7.5 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 8.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 9.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 10.5 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 11.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 12.5 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 13.5 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 |
| 14.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 15.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 16.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 17.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 26.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 30.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| 32.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 33.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 36.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| 38.5 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.03 | 0.03 | 0.03 | 0.03 |
| 39.5 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.05 | 0.06 | 0.05 | 0.06 |

**Table 18: Interharmonics – PVI-165.0-TL-DE and PVI-165.0-DE**

| Higher frequency components – PVI-165.0-TL-DE and PVI-165.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| f (kHz) | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 2.1 | 0.04 | 0.08 | 0.08 | 0.13 | 0.16 | 0.16 | 0.16 | 0.16 | 0.14 | 0.12 | 0.16 |
| 2.3 | 0.06 | 0.08 | 0.10 | 0.10 | 0.07 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.10 |
| 2.5 | 0.07 | 0.14 | 0.12 | 0.11 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.14 |
| 2.7 | 0.13 | 0.18 | 0.17 | 0.15 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.19 |
| 2.9 | 0.13 | 0.17 | 0.20 | 0.20 | 0.20 | 0.21 | 0.21 | 0.21 | 0.21 | 0.22 | 0.22 |
| 3.1 | 0.09 | 0.16 | 0.19 | 0.21 | 0.20 | 0.16 | 0.17 | 0.17 | 0.16 | 0.18 | 0.21 |
| 3.3 | 0.06 | 0.11 | 0.15 | 0.10 | 0.11 | 0.08 | 0.07 | 0.08 | 0.09 | 0.10 | 0.15 |
| 3.5 | 0.03 | 0.04 | 0.05 | 0.05 | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| 3.7 | 0.04 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 |
| 3.9 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| 4.1 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 4.3 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.03 |
| 4.5 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 4.9 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.1 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| 5.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 6.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 6.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 6.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 7.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 19: Higher frequency components – PVI-165.0-TL-DE and PVI-165.0-DE**

| **Harmonics – PVI-220.0-TL-DE and PVI-220.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1 | 6.90 | 18.27 | 28.77 | 39.22 | 49.66 | 59.91 | 69.24 | 79.34 | 89.35 | 98.47 | 98.47 |
| 2 | 0.13 | 0.15 | 0.14 | 0.15 | 0.14 | 0.14 | 0.15 | 0.16 | 0.16 | 0.17 | 0.17 |
| 3 | 0.68 | 0.68 | 0.72 | 0.74 | 0.75 | 0.74 | 0.74 | 0.75 | 0.76 | 0.74 | 0.76 |
| 4 | 0.08 | 0.12 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 |
| 5 | 0.95 | 0.94 | 1.09 | 1.29 | 1.41 | 1.61 | 1.71 | 1.79 | 1.78 | 1.82 | 1.82 |
| 6 | 0.03 | 0.05 | 0.06 | 0.07 | 0.07 | 0.08 | 0.07 | 0.07 | 0.07 | 0.07 | 0.08 |
| 7 | 0.54 | 0.57 | 0.79 | 0.85 | 0.78 | 0.73 | 0.64 | 0.56 | 0.49 | 0.41 | 0.85 |
| 8 | 0.01 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 9 | 0.18 | 0.15 | 0.13 | 0.17 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 |
| 10 | 0.01 | 0.03 | 0.03 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 |
| 11 | 0.11 | 0.15 | 0.29 | 0.26 | 0.19 | 0.14 | 0.17 | 0.21 | 0.25 | 0.31 | 0.31 |
| 12 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 |
| 13 | 0.15 | 0.21 | 0.29 | 0.26 | 0.21 | 0.16 | 0.22 | 0.25 | 0.25 | 0.26 | 0.29 |
| 14 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 15 | 0.04 | 0.03 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.04 | 0.04 | 0.04 |
| 16 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 17 | 0.18 | 0.20 | 0.20 | 0.25 | 0.22 | 0.17 | 0.18 | 0.20 | 0.21 | 0.23 | 0.25 |
| 18 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19 | 0.10 | 0.09 | 0.10 | 0.11 | 0.13 | 0.15 | 0.11 | 0.11 | 0.13 | 0.16 | 0.16 |
| 20 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 22 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23 | 0.05 | 0.12 | 0.09 | 0.10 | 0.10 | 0.09 | 0.08 | 0.08 | 0.08 | 0.10 | 0.12 |
| 24 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25 | 0.04 | 0.06 | 0.06 | 0.10 | 0.08 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.10 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.04 | 0.04 | 0.04 | 0.03 | 0.04 |
| 30 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 31 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.03 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 37 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 38 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 40 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.04 | 0.04 | 0.01 | 0.01 | 0.04 |
| 41 | 0.01 | 0.04 | 0.05 | 0.09 | 0.11 | 0.09 | 0.09 | 0.09 | 0.07 | 0.06 | 0.11 |
| 42 | 0.01 | 0.01 | 0.01 | 0.04 | 0.01 | 0.01 | 0.04 | 0.05 | 0.01 | 0.03 | 0.05 |
| 43 | 0.03 | 0.05 | 0.02 | 0.07 | 0.09 | 0.08 | 0.08 | 0.08 | 0.06 | 0.05 | 0.09 |
| 44 | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.04 | 0.05 |
| 45 | 0.01 | 0.06 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.06 |
| 46 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 47 | 0.05 | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.05 |
| 48 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 49 | 0.05 | 0.08 | 0.05 | 0.04 | 0.05 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.08 |
| 50 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| THC | 1.34 | 1.37 | 1.62 | 1.80 | 1.85 | 1.97 | 2.03 | 2.09 | 2.07 | 2.10 | 2.25 |

**Table 20: Harmonics – PVI-220.0-TL-DE and PVI-220.0-DE**

| **Interharmonics – PVI-220.0-TL-DE and PVI-220.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1.5 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 2.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 5.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 6.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 7.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 |
| 8.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 |
| 9.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 |
| 10.5 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 11.5 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 12.5 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 13.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 14.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 15.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 16.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 17.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 26.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 29.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 30.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 31.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 36.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 38.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 |
| 39.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.05 | 0.05 | 0.05 | 0.05 |

**Table 21: Interharmonics – PVI-220.0-TL-DE and PVI-220.0-DE**

| Higher frequency components – PVI-220.0-TL-DE and PVI-220.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| f (kHz) | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 2.1 | 0.04 | 0.07 | 0.07 | 0.11 | 0.14 | 0.14 | 0.14 | 0.14 | 0.12 | 0.10 | 0.14 |
| 2.3 | 0.05 | 0.07 | 0.08 | 0.09 | 0.06 | 0.06 | 0.07 | 0.07 | 0.07 | 0.07 | 0.09 |
| 2.5 | 0.06 | 0.12 | 0.10 | 0.10 | 0.10 | 0.10 | 0.10 | 0.11 | 0.11 | 0.11 | 0.12 |
| 2.7 | 0.11 | 0.15 | 0.14 | 0.13 | 0.16 | 0.15 | 0.15 | 0.16 | 0.16 | 0.17 | 0.17 |
| 2.9 | 0.11 | 0.15 | 0.17 | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.19 | 0.19 |
| 3.1 | 0.08 | 0.14 | 0.16 | 0.18 | 0.18 | 0.14 | 0.15 | 0.15 | 0.14 | 0.16 | 0.18 |
| 3.3 | 0.05 | 0.10 | 0.13 | 0.08 | 0.10 | 0.07 | 0.06 | 0.07 | 0.07 | 0.08 | 0.13 |
| 3.5 | 0.02 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 |
| 3.7 | 0.04 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 |
| 3.9 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| 4.1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.03 | 0.04 |
| 4.3 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.5 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.7 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 4.9 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.1 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 6.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 |
| 6.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 22: Higher frequency components – PVI-220.0-TL-DE and PVI-220.0-DE**

| **Harmonics – PVI-275.0-TL-DE and PVI-275.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1 | 6.90 | 18.27 | 28.77 | 39.22 | 49.66 | 59.91 | 69.24 | 79.34 | 89.35 | 98.47 | 98.47 |
| 2 | 0.11 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.13 | 0.14 | 0.15 | 0.15 | 0.15 |
| 3 | 0.61 | 0.61 | 0.64 | 0.66 | 0.67 | 0.66 | 0.66 | 0.67 | 0.68 | 0.67 | 0.68 |
| 4 | 0.08 | 0.12 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 |
| 5 | 0.85 | 0.84 | 0.97 | 1.15 | 1.26 | 1.44 | 1.53 | 1.60 | 1.59 | 1.63 | 1.63 |
| 6 | 0.03 | 0.04 | 0.06 | 0.06 | 0.06 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.07 |
| 7 | 0.48 | 0.51 | 0.71 | 0.76 | 0.70 | 0.65 | 0.57 | 0.50 | 0.43 | 0.36 | 0.76 |
| 8 | 0.01 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 9 | 0.18 | 0.15 | 0.13 | 0.17 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 |
| 10 | 0.01 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 |
| 11 | 0.10 | 0.13 | 0.26 | 0.23 | 0.17 | 0.12 | 0.16 | 0.19 | 0.22 | 0.27 | 0.27 |
| 12 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 13 | 0.14 | 0.19 | 0.26 | 0.23 | 0.19 | 0.15 | 0.19 | 0.22 | 0.22 | 0.23 | 0.26 |
| 14 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 15 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| 16 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 17 | 0.16 | 0.17 | 0.17 | 0.22 | 0.19 | 0.16 | 0.16 | 0.18 | 0.19 | 0.21 | 0.22 |
| 18 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19 | 0.09 | 0.08 | 0.09 | 0.10 | 0.12 | 0.13 | 0.10 | 0.10 | 0.12 | 0.14 | 0.14 |
| 20 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 22 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23 | 0.05 | 0.11 | 0.08 | 0.09 | 0.09 | 0.08 | 0.07 | 0.07 | 0.08 | 0.09 | 0.11 |
| 24 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25 | 0.03 | 0.05 | 0.05 | 0.09 | 0.07 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.09 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 29 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 37 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| 38 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.03 | 0.03 |
| 40 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.03 | 0.04 | 0.01 | 0.01 | 0.04 |
| 41 | 0.01 | 0.04 | 0.04 | 0.08 | 0.10 | 0.08 | 0.08 | 0.08 | 0.07 | 0.05 | 0.10 |
| 42 | 0.00 | 0.01 | 0.01 | 0.04 | 0.01 | 0.01 | 0.04 | 0.05 | 0.01 | 0.03 | 0.05 |
| 43 | 0.03 | 0.05 | 0.02 | 0.06 | 0.08 | 0.07 | 0.07 | 0.07 | 0.05 | 0.05 | 0.08 |
| 44 | 0.01 | 0.01 | 0.01 | 0.05 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.03 | 0.05 |
| 45 | 0.01 | 0.05 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.05 |
| 46 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 47 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 |
| 48 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 49 | 0.05 | 0.07 | 0.05 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.07 |
| 50 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| THC | 1.20 | 1.23 | 1.45 | 1.61 | 1.65 | 1.77 | 1.82 | 1.87 | 1.86 | 1.88 | 2.01 |

**Table 23: Harmonics – PVI-275.0-TL-DE and PVI-275.0-DE**

| **Interharmonics – PVI-275.0-TL-DE and PVI-275.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1.5 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 2.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 5.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.02 | 0.01 | 0.01 | 0.02 |
| 6.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| 7.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 8.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 9.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 |
| 10.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 |
| 11.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 |
| 12.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 13.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 14.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 15.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 16.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 17.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 26.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27.5 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 |
| 29.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 30.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 31.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 36.5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 38.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 39.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.04 | 0.04 | 0.04 | 0.04 |

**Table 24: Interharmonics – PVI-275.0-TL-DE and PVI-275.0-DE**

| Higher frequency components – PVI-275.0-TL-DE and PVI-275.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| f (kHz) | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 2.1 | 0.03 | 0.06 | 0.06 | 0.10 | 0.13 | 0.12 | 0.12 | 0.13 | 0.11 | 0.09 | 0.13 |
| 2.3 | 0.05 | 0.06 | 0.08 | 0.08 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.08 |
| 2.5 | 0.06 | 0.11 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.09 | 0.10 | 0.10 | 0.11 |
| 2.7 | 0.10 | 0.14 | 0.13 | 0.12 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 |
| 2.9 | 0.10 | 0.13 | 0.15 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.17 | 0.17 |
| 3.1 | 0.07 | 0.12 | 0.15 | 0.16 | 0.16 | 0.12 | 0.13 | 0.13 | 0.12 | 0.14 | 0.16 |
| 3.3 | 0.04 | 0.09 | 0.11 | 0.08 | 0.09 | 0.07 | 0.05 | 0.06 | 0.07 | 0.08 | 0.11 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 3.7 | 0.04 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 |
| 3.9 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 |
| 4.1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.3 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.5 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.7 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 4.9 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 5.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 25: Higher frequency components – PVI-275.0-TL-DE and PVI-275.0-DE**

| **Harmonics – PVI-330.0-TL-DE and PVI-330.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1 | 6.90 | 18.27 | 28.77 | 39.22 | 49.66 | 59.91 | 69.24 | 79.34 | 89.35 | 98.47 | 98.47 |
| 2 | 0.10 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.12 | 0.13 | 0.13 | 0.14 | 0.14 |
| 3 | 0.55 | 0.56 | 0.59 | 0.60 | 0.61 | 0.61 | 0.60 | 0.61 | 0.62 | 0.61 | 0.62 |
| 4 | 0.08 | 0.12 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.13 | 0.14 | 0.13 | 0.14 |
| 5 | 0.77 | 0.77 | 0.89 | 1.05 | 1.15 | 1.32 | 1.40 | 1.46 | 1.45 | 1.49 | 1.49 |
| 6 | 0.03 | 0.04 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| 7 | 0.44 | 0.47 | 0.65 | 0.69 | 0.64 | 0.59 | 0.52 | 0.45 | 0.40 | 0.33 | 0.69 |
| 8 | 0.01 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 9 | 0.18 | 0.15 | 0.13 | 0.17 | 0.15 | 0.16 | 0.17 | 0.17 | 0.17 | 0.17 | 0.18 |
| 10 | 0.01 | 0.02 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 |
| 11 | 0.09 | 0.12 | 0.23 | 0.21 | 0.16 | 0.11 | 0.14 | 0.17 | 0.20 | 0.25 | 0.25 |
| 12 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 13 | 0.12 | 0.17 | 0.24 | 0.21 | 0.17 | 0.13 | 0.18 | 0.20 | 0.20 | 0.21 | 0.24 |
| 14 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 15 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 | 0.03 | 0.03 | 0.03 |
| 16 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 17 | 0.14 | 0.16 | 0.16 | 0.20 | 0.18 | 0.14 | 0.15 | 0.16 | 0.17 | 0.19 | 0.20 |
| 18 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19 | 0.08 | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.09 | 0.09 | 0.11 | 0.13 | 0.13 |
| 20 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 22 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23 | 0.04 | 0.10 | 0.07 | 0.08 | 0.08 | 0.08 | 0.06 | 0.07 | 0.07 | 0.08 | 0.10 |
| 24 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 |
| 25 | 0.03 | 0.05 | 0.05 | 0.08 | 0.07 | 0.05 | 0.05 | 0.06 | 0.05 | 0.06 | 0.08 |
| 26 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 |
| 27 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 28 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 |
| 29 | 0.01 | 0.02 | 0.02 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 36 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| 37 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.04 | 0.04 |
| 38 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| 39 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 | 0.03 | 0.03 |
| 40 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.03 | 0.03 | 0.01 | 0.01 | 0.03 |
| 41 | 0.01 | 0.03 | 0.04 | 0.07 | 0.09 | 0.07 | 0.07 | 0.07 | 0.06 | 0.05 | 0.09 |
| 42 | 0.00 | 0.01 | 0.01 | 0.03 | 0.01 | 0.01 | 0.03 | 0.04 | 0.01 | 0.02 | 0.04 |
| 43 | 0.03 | 0.04 | 0.02 | 0.06 | 0.08 | 0.06 | 0.06 | 0.06 | 0.05 | 0.04 | 0.08 |
| 44 | 0.01 | 0.01 | 0.01 | 0.04 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.03 | 0.04 |
| 45 | 0.01 | 0.05 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.03 | 0.01 | 0.02 | 0.05 |
| 46 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 47 | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.02 | 0.04 |
| 48 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 49 | 0.04 | 0.07 | 0.04 | 0.04 | 0.04 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.07 |
| 50 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 |
| THC | 1.10 | 1.13 | 1.33 | 1.48 | 1.51 | 1.61 | 1.66 | 1.71 | 1.70 | 1.72 | 1.84 |

**Table 26: Harmonics – PVI-330.0-TL-DE and PVI-330.0-DE**

| **Interharmonics – PVI-330.0-TL-DE and PVI-330.0-DE** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| order | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 1.5 | 0.01 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 | 0.02 | 0.03 |
| 2.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.04 | 0.03 | 0.03 | 0.04 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 |
| 5.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 6.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 7.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 8.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 9.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 10.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 |
| 11.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.02 |
| 12.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 13.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 14.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 15.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 16.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 17.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 18.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 19.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 20.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 21.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 22.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 23.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 24.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 25.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 26.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 27.5 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| 28.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 29.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 30.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 31.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 32.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 33.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 34.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 35.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 36.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 37.5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 38.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 |
| 39.5 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.04 | 0.04 | 0.04 | 0.04 |

**Table 27: Interharmonics – PVI-330.0-TL-DE and PVI-330.0-DE**

| Higher frequency components – PVI-330.0-TL-DE and PVI-330.0-DE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $I/I_N$ (%) | Power bin ($P/P_N$) | | | | | | | | | | |
| f (kHz) | 0-10% | 10-20% | 20-30% | 30-40% | 40-50% | 50-60% | 60-70% | 70-80% | 80-90% | 90-100% | highest value |
| 2.1 | 0.03 | 0.06 | 0.06 | 0.09 | 0.12 | 0.11 | 0.11 | 0.12 | 0.10 | 0.08 | 0.12 |
| 2.3 | 0.04 | 0.06 | 0.07 | 0.07 | 0.05 | 0.05 | 0.05 | 0.06 | 0.06 | 0.05 | 0.07 |
| 2.5 | 0.05 | 0.10 | 0.08 | 0.08 | 0.08 | 0.08 | 0.08 | 0.09 | 0.09 | 0.09 | 0.10 |
| 2.7 | 0.09 | 0.12 | 0.12 | 0.11 | 0.13 | 0.13 | 0.12 | 0.13 | 0.13 | 0.14 | 0.14 |
| 2.9 | 0.09 | 0.12 | 0.14 | 0.14 | 0.14 | 0.15 | 0.15 | 0.15 | 0.15 | 0.16 | 0.16 |
| 3.1 | 0.06 | 0.11 | 0.13 | 0.15 | 0.14 | 0.11 | 0.12 | 0.12 | 0.11 | 0.13 | 0.15 |
| 3.3 | 0.04 | 0.08 | 0.10 | 0.07 | 0.08 | 0.06 | 0.05 | 0.05 | 0.06 | 0.07 | 0.10 |
| 3.5 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 |
| 3.7 | 0.04 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 |
| 3.9 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 |
| 4.1 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 |
| 4.3 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 |
| 4.5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 4.7 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 4.9 | 0.00 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| 5.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 7.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8.9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Table 28: Higher frequency components – PVI-330.0-TL-DE and PVI-330.0-DE**

## 3.9. Cut-in conditions

FGW TR8 specifies that the unit must not connect to the grid outside the limits specified in the table below. According to the IWES test report, the measurements according to FGW TR3 confirmed that no connection to the grid occurred outside the limits.

| | connection limit |
|---|---|
| undervoltage | U < 0.95 $U_N$ |
| underfrequency | f < 47.50 Hz |
| overfrequency | f > 50.05 Hz |

## 3.10. Fault Ride through

The PVI-55.0-TL-DE inverter was tested for behavior during a grid low voltage event according to FGW TR3 section 4.7. The following tests were included in the measurements:

- symmetrical (3-phase) faults with K=2
- additional 3-phase tests with K=0 and K=3
- additional 3-phase tests (not required by TR3) demonstrating correct behavior for deviating voltage $U_0$ or static reactive current $I_{B0}$ before the fault
- asymmetrical (2-phase) faults assuming a grid connection using a Dy-type MV transformer and the transformer-less version of the inverter (Dy configuration)
- asymmetrical (2-phase) faults assuming a grid connection using a Dd-type MV transformer and the transformer-less version of the inverter, or a Dyn-type MV transformer in combination with a PVI-xxx.x-DE inverter including isolation transformer, or an equivalent configuration (Ddconfiguration)

### 3.10.1. LVRT characteristics and K factor setting

LVRT mode is activated when the grid voltage leaves the dead range [0.9 $U_N$, 1.1 $U_N$] and remains active until 500 ms after U has returned into the dead band.

For symmetric faults, reactive current is provided according to TC2007 requirements. The K factor may be set from 0 to 3. Higher values are not covered by the Power One specification and the certification.

The internal value of VAR61, corresponding to the K parameter, must be set as follows:

| Required K factor | Internal setting VAR61 (V) |
|---|---|
| 0 | 0 |
| 0 < K ≤ 3 | K + 0.4 |
| K > 3 | not allowed |

For asymmetric faults with depth 50% and lower, no reactive current is injected. For 75% asymmetric faults, active and reactive current shows an oscillating behavior (see section4.4).

### 3.10.2. Results of FRT tests

All requirements were fulfilled in the tests. Grid support by additional reactive power was provided during the faults as required. Tests were done on the 320 V level. The results are applicable for the entire PVI-xxx.x-DE and PVI-xxx.x-TL-DE series of inverters.

| **Results of FRT tests – symmetric faults** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Test conditions | | | | Test results | | | | | | | |
| Test No. [1] | $U/U_N$ level [2] | fault duration [3] (ms) | Active power [3] (% $P_N$) | $U/U_N$ level [3] | $U_0/U_N$ [3] | $I_B/I_N$ req. [4] | $I_B/I_N$ meas. | $t_{react}$ (ms) [5] | $t_{settle}$ (ms) [6] | $t_{90\% PN}$ (s) | Assess-ment |
| 3-phase, partial load (K=2) | | | | | | | | | | | |
| 1.1.2_ | 4.0% | 149.7 | 19.7% | 8.3% | 98.3% | - | 91.6% | - | - | 0.12 | OK |
| 2.1.2_ | 22.5% | 549.5 | 19.7% | 26.6% | 98.3% | 100.0% | 92.5% | 49.0 | 49.0 | 0.12 | OK |
| 3.1.2.a | 50.0% | 949.7 | 19.7% | 53.5% | 98.3% | 89.3% | 92.5% | 40.7 | 40.7 | 0.12 | OK |
| 4.1.2.a | 75.0% | 1399.7 | 19.7% | 76.0% | 98.3% | 44.4% | 49.1% | 34.7 | 34.7 | 0.12 | OK |
| | | | | | | | | | | | |
| 3-phase, full load (K=2) | | | | | | | | | | | |
| 1.1.1_ | 4.0% | 149.7 | 94.6% | 8.3% | 98.9% | - | 91.4% | - | - | 0.19 | OK |
| 2.1.1_ | 22.5% | 549.6 | 94.6% | 26.3% | 98.9% | 100.0% | 92.5% | 49.6 | 49.6 | 0.11 | OK |
| 3.1.1.a | 50.0% | 950 | 94.6% | 53.0% | 98.9% | 94.6% | 92.5% | 44.0 | 44.0 | 0.11 | OK |
| 4.1.1.a | 75.0% | 1400 | 94.6% | 75.4% | 98.9% | 49.8% | 52.0% | 35.0 | 35.0 | 0.11 | OK |
| | | | | | | | | | | | |
| 3-phase, K=0 | | | | | | | | | | | |
| 3.1.2.o | 50.0% | 950 | 19.7% | 49.2% | 98.3% | 0.0% | -0.1% | - | - | 0.12 | OK |
| 3-phase, K=3 | | | | | | | | | | | |
| 3.1.2.b | 50.0% | 950 | 19.7% | 53.5% | 98.3% | 100% | 67.1% | 49.4 | 49.4 | 0.12 | OK |
| 4.1.2.b | 75.0% | 1400 | 19.7% | 76.9% | 98.3% | 64.2% | 92.4% | 37.0 | 37.0 | 0.12 | OK |
| Lin | 80.0% | 1400 | 19.7% | 82.6% | 98.3% | 47.00% | 49.0% | 35.7 | 35.7 | 0.11 | OK |
| 3-phase, deviating $I_{B0}$ and $U_0$ | | | | | | | | | | | |
| $I_{B0}>0$ | 50.0% | 950 | 19.5% | 53.5% | 98.5% | 93.9% | 92.4% | 44.0 | 44.0 | 0.12 | OK |
| $I_{B0}<0$ | 50.0% | 950 | 19.8% | 53.2% | 98.1% | 85.6% | 84.9% | 43.0 | 43.0 | 0.12 | OK |
| $U_0<U_N$ | 50.0% | 950 | 19.8% | 53.4% | 93.5% | 80.1% | 88.6% | 37.2 | 37.2 | 0.12 | OK |

**Table 29: 3-phase Fault ride through tests performed**

| **Results of FRT tests – asymmetric faults** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Test conditions | | | | Test results | | | | | | | |
| Test No. [1] | $U/U_N$ level [2] | fault duration [3] (ms) | Active power [3] (% $P_N$) | $U/U_N$ level [3] | $U_0/U_N$ [3] | $I_B/I_N$ req. [4] | $I_B/I_N$ meas. | $t_{react}$ (ms) [5] | $t_{settle}$ (ms) [6] | $t_{90\% PN}$ (s) | Assess-ment |
| 2-phase, partial load, Dy transformer configuration (K=2) | | | | | | | | | | | |
| 1.2.2_ | 4.0% | 149.7 | 19.6% | 51.0% | 98.4% | - | -0.2% | - | - | 0.15 | OK |
| 2.2.2_ | 22.5% | 550.1 | 19.6% | 60.5% | 98.4% | - | -0.1% | - | - | 0.14 | OK |
| 3.2.2.a | 50.0% | 949.5 | 19.6% | 73.6% | 98.4% | - | -0.2% | - | - | 0.13 | OK |
| 4.2.2.a | 75.0% | 1399.7 | 19.6% | 86.2% | 98.4% | - | 3.6-20% [7] | - | - | 0.16 | OK |
| | | | | | | | | | | | |
| 2-phase, full load, Dy transformer configuration (K=2) | | | | | | | | | | | |
| 1.2.1_ | 4.0% | 150.2 | 95.4% | 51.0% | 99.8% | - | -0.2% | - | - | 0.13 | OK |
| 2.2.1_ | 22.5% | 550.4 | 95.4% | 60.5% | 99.8% | - | -0.2% | - | - | 0.14 | OK |
| 3.2.1.a | 50.0% | 949.5 | 95.4% | 73.6% | 99.8% | - | -0.2% | - | - | 0.13 | OK |
| 4.2.1.a | 75.0% | 1399.6 | 95.4% | 86.5% | 99.8% | - | 4-23% [7] | - | - | 0.16 | OK |
| | | | | | | | | | | | |
| 2-phase, partial load, Dd transformer configuration (K=2) | | | | | | | | | | | |
| 1.2.2_ | 4.0% | 150 | 20.5% | 51.2% | 98.4% | - | -0.3% | - | - | 0.14 | OK |
| 2.2.2_ | 22.5% | 550.2 | 20.5% | 59.3% | 98.4% | - | 0.1% | - | - | 0.13 | OK |
| 3.2.2.a | 50.0% | 949.4 | 20.5% | 73.9% | 98.4% | - | -0.3% | - | - | 0.13 | OK |
| 4.2.2.a | 75.0% | 1399.6 | 20.5% | 86.3% | 98.4% | - | 3.6-20% [7] | - | - | 0.11 | OK |
| | | | | | | | | | | | |
| 2-phase, full load, Dd transformer configuration (K=2) | | | | | | | | | | | |
| 1.2.1_ | 4.0% | 150.1 | 94.7% | 50.7% | 98.9% | - | -0.3% | - | - | 0.15 | OK |
| 2.2.1_ | 22.5% | 550 | 94.7% | 59.8% | 98.9% | - | -0.3% | - | - | 0.13 | OK |
| 3.2.1.a | 50.0% | 950.2 | 95.5% | 73.9% | 99.8% | - | -0.3% | - | - | 0.13 | OK |
| 4.2.1.a | 75.0% | 1399.6 | 95.5% | 86.7% | 99.8% | - | 4-23% [7] | - | - | 0.17 | OK |

**Table 30: 2-phase Fault ride through tests**

Remarks:

1) *Test number as defined in FGW TR3 section 4.7, table 3, and also referred to by the IWES report.*
2) *Nominal value, without tested equipment*
3) *Positive sequence value determined from measurements. For asymmetric faults, the value differs from the nominal value because of the definition of positive sequence voltage.*
4) *Required reactive current calculated from measured $U_0$, U and $I_{B0}$.*
5) *Reaction time (time until [-10% $U_N$, +20% $U_N$] tolerance band around required value is first reached*
6) *Settling time (time until [-10% $U_N$, +20% $U_N$] tolerance band around required value is reached finally.*
7) *Reactive current shows pulsing behavior, see following section*

### 3.10.3. Short circuit current contribution

The worst-case short circuit current contribution of the inverters during a grid fault according to BDEW section 6.4.2 is specified in the following table. Values are given relative to the nominal current $I_N$. They are therefore valid for all inverters covered by this certificate. For symmetric faults at t > 0 and with K > 0, the short circuit current is mainly determined by overexcited reactive current injection.

For all symmetric faults, the injected current reaches a constant value within 100 ms after fault beginning. Therefore for all times t > 100 ms, the values specified for t = $t_{end}$ may be used.

| **Short circuit current contribution (PVI-xxx.x-DE and PVI-xxx.x-TL-DE)** | | | | | |
|---|---|---|---|---|---|
| Fault depth | fault duration (ms) | $I_K''/I_N$ t = 0 1) | $\hat{I}_K''/I_N$ t = 0 2) | $I_K''/I_N$ t = 150 ms 3) | $I_K''/I_N$ t = $t_{end}$ 4) |
| Symmetric faults, K=0 6) | | | | | |
| 50.0% | 950 | 0.22 | 0.31 | 0.11 | 0.11 |
| Symmetric faults, K=2 | | | | | |
| 4.0% | 150 | 0.82 | 1.16 | - | 0.93 |
| 22.5% | 550 | 0.82 | 1.16 | 0.94 | 0.94 |
| 50.0% | 950 | 0.84 | 1.19 | 0.94 | 0.94 |
| 75.0% | 1400 | 0.5 | 0.71 | 0.54 | 0.54 |
| Symmetric faults, K=3 5) | | | | | |
| 50.0% | 950 | 0.82 | 1.16 | 0.95 | 0.94 |
| 75.0% | 1400 | 0.63 | 0.89 | 0.69 | 0.69 |
| 80.0% | 1400 | 0.46 | 0.65 | 0.51 | 0.51 |
| Asymmetric faults | | | | | |
| 4.0% | 150 | 0.53 | 0.75 | - | 0.16 |
| 22.5% | 550 | 0.49 | 0.69 | 0.15 | 0.15 |
| 50.0% | 950 | 0.41 | 0.58 | 0.13 | 0.13 |
| 75.0% | 1400 | 0.55 | 0.78 | 0.55 | 0.55 |
| **Worst case over all faults** | | | | | |
| | | **0.84** | **1.19** | **0.95** | **0.94** |

Table 31: short circuit current contribution

Definitions and remarks:

1) rms value over first half period after fault beginning
2) peak value over first half period after fault beginning ($\sqrt{2} \times I_K''$)
3) rms value over full-period at 150 ms after fault beginning. For 4% faults, this value is not meaningful; use the value at t = $t_{end}$.
4) rms value over last full period before fault clearing
5) For 4% and 22.5% depth, values from K=2 may be used
6) For other voltage depths with setting K=0, values may be assumed to be similar.

## 3.11. Grid protection

The PVI-xxx.x(-TL)-DE inverters have integrated under/over-voltage and under/over-frequency grid protection facilities. The tests have shown that grid protection works correctly according to the tolerances defined in FGW TR8 within the following ranges:

| | range of trip limit setting tested | operating time tested | range of operating time |
|---|---|---|---|
| overvoltage protection $U_{>>}$ | 1.0 – 1.25 $U_N$ | ≤ 100 ms | [1)] |
| undervoltage protection $U_{<}$ | 0.1 – 1.0 $U_N$ | 1000 ms | 0 – 3000 ms |
| undervoltage protection $U_{<<}$ | 0.1 – 1.0 $U_N$ | 300 ms | 0 – 500 ms |
| overfrequency protection $f_{>}$ | 50.0 – 52.0 Hz | ≤ 100 ms | [1)] |
| underfrequency protection $f_{<}$ | 47.5 – 50.0 Hz | ≤ 100 ms | [1)] |

Table 32: Ranges of grid protection settings

Remarks:

1) To realise an operating time of ≤ 100 ms including breaker operating time, the trip time must be internally set to a value of 10 ms.

## 3.12. Active power ramp rate control

The active power ramp rate after a grid fault was determined to be 9.4% $P_N$/min and therefore conforms to the requirements. Ramp rate control is activated by setting inverter variable 71 (CVI No.) to 1.

In PV installations > 1 MVA total power, ramp rate control must be activated for conformity with the BDEW medium voltage guideline /5/.

# 4. Validated model of the unit

## 4.1. Description of the open model provided by the manufacturer

Power One has provided a textual description of the regulation algorithms used in the inverter and of the logic used for the detection of symmetrical and asymmetrical grid faults /8/.

## 4.2. Description of the executable model

Power One has provided an executable model implemented in the MATLAB / Simulink environment. It is realised as a Simulink block which uses the instantaneous line-to-earth voltage of the three phases as input and outputs the three instantaneous line currents of the inverter.

Only the 'POWER_ONE INVERTER' Simulink block and its associated files (message.mexw32, Parameters_DLL_13.m and POWER_ONE_sf.mexw32) are included in the scope of the validation. The 'MEDIUM VOLTAGE GRID' block and the file 'Graf_Dll_13.m' are not part of the validated model. The settings in Parameters_DLL_13.m must be loaded before the start of the simulation.

The model operates in fixed step mode with a time interval of 1/(360 kHz).

Behavior of the inverter is modeled at the 320V terminals of the transformer-less55 kW version of the inverter. To model the higher power versions of the inverter, the line currents may be multiplied by the number of 55 kW modules using the appropriate Simulink elements.

For the PVI-xxx.x-DE inverters, an additional simulation of the inverter's integrated isolation transformer must be used. Transformer specifications are given in Table 1.

The model automatically switches to a negative sequence mode when a negative sequence grid voltage is applied to its inputs. Validation does not cover the negative sequence mode; i.e. the model must be operated in positive sequence mode.

The following properties of the inverter are implemented in the model:

| | Implemented in Simulink model | Included in certification |
|---|---|---|
| LVRT: symmetrical faults | yes | yes |
| LVRT: unsymmetrical faults | yes | yes |
| variable K factor for LVRT | yes | yes (K = 0 … 3) |
| variable output power (static) | yes | yes |
| reactive power set-point control (static) | yes | yes |
| grid protection | undervoltage only ($U_<$ and $U_{<<}$) | no |

Table 33: Implemented model features

## 4.3. Model package and checksum

The model package contains all necessary files to run the model in the MATLAB/Simulink environment (R2010a) and the associated documentation. One of the checksums of the package file should be verified by the user to ensure that the model is identical to the validated version.

| | |
|---|---|
| **Model version** | 13 |
| **Model archive** | Model-PowerOne-PVI-xxx.x(-TL)-DE-v13.zip |
| **Contained files** | DLL_13.mdl<br>Graf_Dll_13.m<br>message.mexw32<br>Parameters_DLL_13.m<br>POWER_ONE_sf.mexw32<br>Power_One_Inverter_Model_13_Explanation_02.pdf |
| **MD5 checksum of archive** | 3cf31469e18b6f19ef669661d9fcdaa1 |
| **SHA1 checksum of archive** | 3ab699aa6e0e1fad32a3216877ec7e2c8f0bb354 |

Table 34: Model identification

## 4.4. Deviations between model results and results of the test report

The model output has been validated against the LVRT typetests described in section 3.10. Details of the validation are described in report /10/. Generally, the model shows very good agreement of active and reactive current with the real inverter behavior (see Figure 12 as an example). Reaction times of the model are slightly longer than reality in many cases.

An exception are shallow asymmetrical faults (80% voltage depth), the real inverter shows a pulsing behavior of active and reactive current, while the model only reproduces the average values during the fault (Figure 13).

Deviations of P, Q and $I_Q$ values were found to be within the tolerances specified by FGW TR4 /3/ for all tests, including tests with K=0 and K=3 and tests with pulsing behavior.

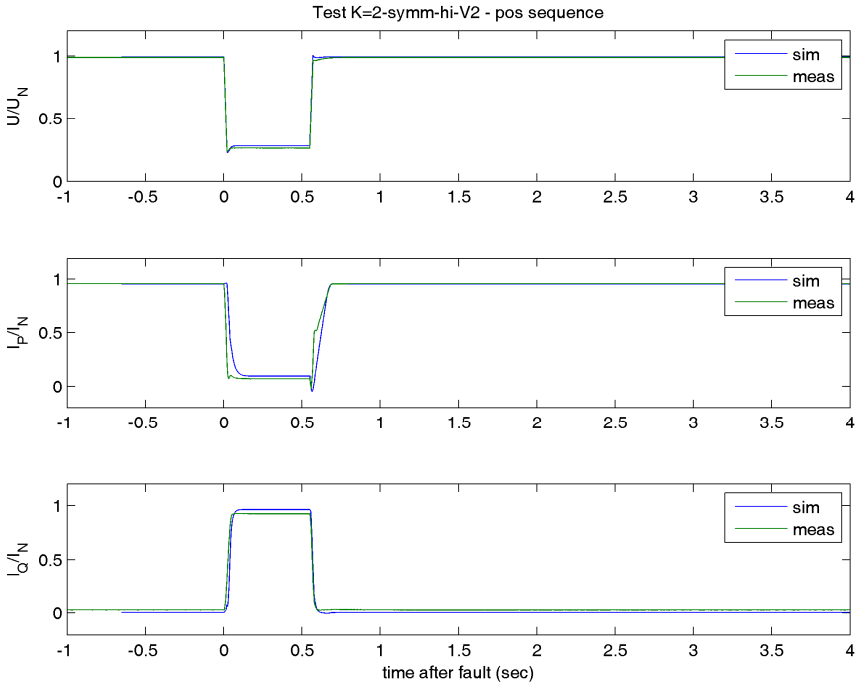


**Figure 12: comparison of model and real inverter behavior for a symmetric voltage dip to 22.5% of nominal voltage at full load**

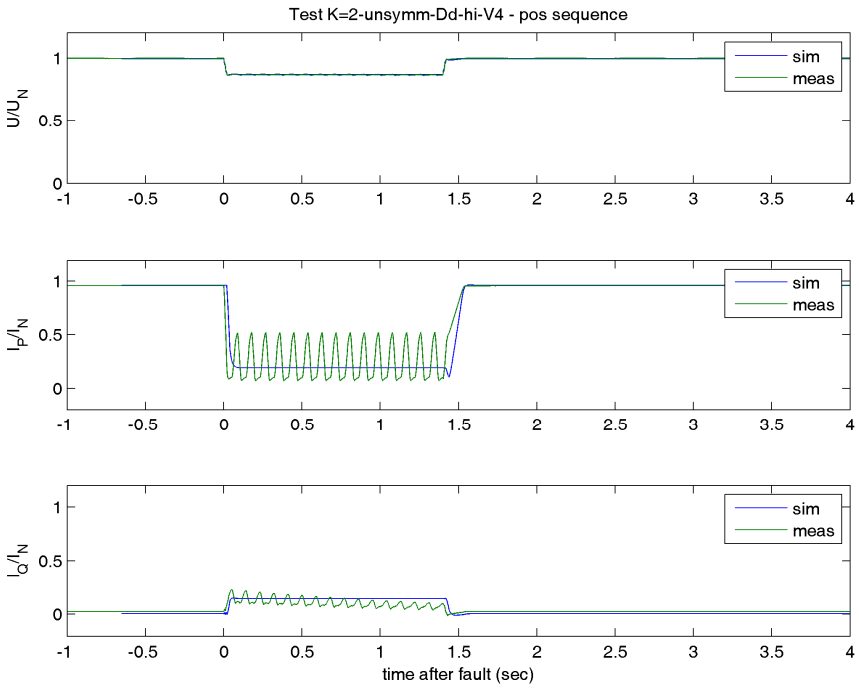


**Figure 13: comparison of model and real inverter behavior for an asymmetrical voltage dip to 80% of nominal voltage at full load, showing oscillating behavior of the real inverter**

## 4.5. Short description of further tests performed

Additionally, plausibility tests according to FGW TR8 section 6.2.2 were performed, including

1) single faults with 10 – 95 % voltage depth in steps of 5%, symmetric and asymmetric
2) double faults (failed automatic reconnection) with 25%, 50% and 75% depth, symmetric and asymmetric
3) fault with voltage step function (protection failure) with 25%/50% and 50%/75% depth, symmetric and asymmetric

The following additional tests, not required by regulations, have been performed:

1) step function 50%/95% (correct behavior after fault clearing)
2) behavior of Q set-point control at full and partial load, limitation behavior of static Q and $I_Q$
3) LVRT with variation of initial voltage
4) LVRT with K = 0 … 3 in steps of 0.5
5) LVRT with 0 to 6% voltage depth
6) over-voltage events with variation of initial voltage

For the symmetrical voltage drop to 80% at K=2, the model produced reactive current slightly below the lower limit according to FGW TR8. However, the real inverter performed fully according to the requirements in the same test and the deviation between model and inverter is within the tolerance. Otherwise, in all tests, the tested model behavior was found to be in accordance with TR8 Rev. 04 / BDEW 2008 requirements /2,5/ and the specified inverter behavior.

# 5. Restrictions and Conditions

## 5.1. Type of power source

The certification is only valid for use in PV installations.

## 5.2. Configurations settings

Configuration settings of the inverter must be set according to the following table.

| description | variable | value / usable range | unit | remark |
|---|---|---|---|---|
| U>><br>AC Overvoltage (phase to phase) Trip limit | VAR26 | 320 – 400<br>(1.0 – 1.25 $U_N$) | Vac | 5) |
| U>>
AC Overvoltage (phase to phase) Trip time | VAR27 | 10 | msec | 1) |
| U<
AC Under voltage (phase to phase) before connection | VAR28 | 304.0 | Vac | |
| f<
AC Under Frequency | VAR35 | 47.50 – 50.00 | Hz | 2) |
| f>
AC Over Frequency After Connection | VAR36 | 50.00 – 51.50 | Hz | 2) |
| K factor for Grid voltage support | VAR61 | 0 – 3 | | 4) |
| U<<
AC Under voltage (phase to phase) Trip limit | VAR64 | 32 – 320<br>(0.1 – 1.0 $U_N$) | Vac | 2) 3) |
| U<<
AC Under voltage (phase to phase) Trip time | VAR65 | 0 – 500 | msec | 2) |
| Maximum active current | VAR66 | 140.3 – 148.5 | A (peak) | 7) |
| U<
AC Under voltage (phase to phase) after connection trip limit | VAR69 | 32 – 320<br>(0.1 – 1.0 $U_N$) | Vac | 2) 3) |
| U<
AC Under voltage (phase to phase) after connection trip time | VAR70 | 0 – 3000 | msec | 2) |
| Enable of Active power ramp-up during re-connection after grid fault | VAR71 | 0=Disable<br>1=Enable | | 2) 6) |
| Frequency threshold to restore full power after Power derating vs Frequency | VAR72 | 50.04 | Hz | |
| Threshold to start with Power derating vs Frequency | VAR73 | 50.20 | Hz | |

Table 35: Requirements for configuration settings

Remarks:

1) setting of 10 msec will ensure an actual trip time ≤ 100 msec. If a longer trip time is required, variable should be set to the required value.
2) set as required by grid operator. Nominal voltage is $U_N$ = 320 V.
3) the value of variable 64 shall be lower than variable 69.
4) Internal value of VAR61 must be corrected according to section 3.10.1

5) Value must be set using Power One's PC-based configuration software "50Kw AURORA Test" version 1.0.6, or using the correction in Table 36. In the configuration software, the correction is included.
6) For PV installations > 1 MVA total power, ramp rate control must be activated for BDEW conformity.
7) Refer to sections 3.2 and 3.5.1.

| **Required voltage limit** | | **Internal setting** |
|---|---|---|
| **$U_>$ / $U_N$** | **$U_>$ (V)** | **VAR26 (V)** |
| 1.0 – 1.15 | 320 – 368.0 | same as required value |
| 1.16 | 371.2 | 371.1 |
| 1.17 | 374.4 | 373.8 |
| 1.18 | 377.6 | 376.3 |
| 1.19 | 380.8 | 378.6 |
| 1.20 | 384.0 | 380.8 |
| 1.21 | 387.2 | 382.9 |
| 1.22 | 390.4 | 384.9 |
| 1.23 | 393.6 | 386.8 |
| 1.24 | 396.8 | 388.6 |
| 1.25 | 400.0 | 390.4 |

Table 36: Correction for $U_>$ limit setting

## 5.3. Grid connection

The scope of the certification is for generating plants connected to the German medium voltage (MV) distribution grid /5/.

One of the following grid connection layouts must be used:

1) Transformer-less version of the inverter (PVI-xxx.x-TL-DE), or multiple inverters of this type connected in parallel, connected to the MV grid through a delta-star type (Dy) transformer (with 320V rated voltage on its LV side).

2) Transformer-less version of the inverter (PVI-xxx.x-TL-DE), or multiple inverters of this type connected in parallel, connected to the MV grid through a delta-delta type (Dd) transformer (with 320V rated voltage on its LV side).

3) Inverter with integrated isolation transformer (PVI-xxx.x-DE), or multiple inverters of this type connected in parallel, connected to the MV grid through an additional Delta-star (Dyn) transformer (with 400V rated voltage on its LV side).

4) Any transformer layout where the phase vector transformation between the MV side and the 320V inverter terminals for asymmetric grid faults in the MV grid is equivalent to one of the above layouts 1-3.

For other grid connection layouts, correct behavior of the inverters in the event of unsymmetrical grid faults is not covered by the type tests and the certification.

### 5.4. Active and reactive power set-point control

Active and reactive power set-point control (if required by the grid operator) must be implemented by one of the following means:

1. By four relay contacts (K1-K4) or analog 4-20 mA interface using the AURORA PVI-PMU power management unit, connected to all inverters via the RS-485 bus, and exclusively using the control modes as described in sections 3.4 and 3.6.

2. Use of a farm controller unit which uses the AURORA communication protocol (as documented in /7/) to control active and reactive power, using exclusively the RS485 command formats described in sections 3.4 and 3.6.

If regulation of Q and P at the PCC, or a cos φ(P) or Q(U) characteristic is required, suitable equipment according to option (2) must be used.

Direct control of cos φ by RS485 was found to exceed the permitted tolerance ± 0.005 in the measurements at maximum under-/overexcited set-points. If this mode is used without regulation, behavior of reactive power at the PCC must be assessed considering influences of transformers and cables.

## 6. Summary of certificate data

| Manufacturer | Type | Rated Power | Date of Issue | End of Validity | Unit Certificate Number |
|---|---|---|---|---|---|
| Power-One Italy S.p.A. | PVI-xxx.x-TL-DE and PVI-xxx.x-DE series | 55 kW<br>110 kW<br>165 kW<br>220 kW<br>275 kW<br>330 kW | 07.08.2013 | 22.12.2015 | 09-0326-14 |

| Number of validated Model / MD5 checksum | Software of validated model | Valid Software version | State | Specification | Guidelines |
|---|---|---|---|---|---|
| MD5 checksum: 3cf31469e18b6 f19ef669661d9 fcdaa1 | MATLAB Simulink R2010a | Inverter DSP: A.F.3.2 or E.F.1.1<br><br>Inverter Microprocessor: B.F.0.9 or F.F.1.1<br><br>PVI-PMU: Rev.11 | current | | BDEW technical guideline, Generating Plants connected to the Medium-Voltage Network, 2008 and supplement 7/2010 |

# 7. References

/1/ FGW technical guideline TR3 Rev. 21

/2/ FGW technical guideline TR8 Rev. 04

/3/ FGW technical guideline TR4 Rev. 05

/4/ M.O.E., QMP 01 Einheitenzertifizierung Rev. 01

/5/ BDEW technical guideline, Generating Plants Connected to the Medium-Voltage Network, June 2008

/6/ BDEW supplement to the medium voltage guideline, Regelungen und Übergangsfristen, July 2010

/7/ Power One, Aurora Inverter Series – Communication Protocol, Rel. 4.7, 2009-05-19, AuroraCommunicationProtocol_4_7_PUBLIC.pdf and Aurora Power Reduction, Rev.10, AN101-Aurora Power Reduction - 10.pdf

/8/ Power One, Manufacturer declaration, Inverter control and fault detection logic, 2010-12-10, PVI-XXX.X(-TL)_Working Principle_Rev-Dec 10-2010.pdf

/9/ M.O.E., Assessment report solar inverters, PowerOne PVI-xxx.x-TL-DE and PVI-xxx.x-DE, M.O.E. report no. 09-0326-06

/10/ M.O.E., Model validation report for the PowerOne Simulink model for PVI-xxx.x(-TL)-DE central solar inverters, version 13, M.O.E. report no. 09-0326-07

/11/ Fraunhofer IWES, Test report 10-016A, “Tests according to FGW TR3 Rev. 21 for PV-inverter PVI-Central-55 without transformer“, issued 2011-12-08

/12/ Fraunhofer IWES, Test report 10-025, “Current harmonic measurement according to FGW TR3 Rev. 21 for PV inverter PVI-Central-110 without transformer“, issued 2010-12-22