



Palmer Solar and Williams Creek Substation Noise Impact Study

Prepared by Brandon Aho, Electrical Engineer, EIT

Revision	Description	Date	Prepared By	Checked By
0	Initial Issue	08/07/2017	BDA	JPT

Introduction

Electric power generation facilities utilize electrical and mechanical machinery which have the potential to create a significant amount of audible sound in the form of noise. This noise has the potential to disturb the peace and present a nuisance to nearby property owners. The magnitude of this noise which is audible at the property boundary must be at a level that is within acceptable limits according to the local authority having jurisdiction, or AHJ.

Sound pressure level (sound level) is defined as the logarithmic measure of the effective pressure of a sound relative to the threshold of human hearing – $20\mu\text{Pa}$ – and is measured in A-weighted dB, or dBA. As the human ear is sensitive to frequencies only within a specific band, the sound pressure level created by industrial equipment is measured by recording instruments which apply a filter according to the A-weighting, meaning that sounds that fall outside of the human range of hearing are weighted less than sounds which fall inside the human range of hearing.

Sound power level is defined as the rate at which sound energy is emitted from the source and is also measured logarithmically relative to the threshold of human hearing – 10^{-12}W/m^2 – and is measured in dBA. For the purposes of this noise impact study, the standard specific acoustic impedance of air $Z_0=400\text{Pa}$ is assumed.

Acceptable Sound Level

The Palmer Solar generating facility is proposed to be located in El Paso County, Colorado and will generate electric power as early as 5:30AM and as late as 8:30PM depending on the day of the year. According to El Paso County Ordinance No. 02-1 *Ordinance Concerning Noise Levels in Unincorporated El Paso County* (Appendix A), a maximum permissible sound pressure level of 50dBA shall be observed at the boundaries between the Palmer Solar facility and any residential property, commercial, or non-specified area.

Equipment Identified

The following equipment was determined to create significant sound levels which will be considered in this noise impact study:

1. 63.8MVA substation transformer
2. 3.36MVA power station transformer
3. Solar PV inverter option #1 – TMEIC PVH-L3360GR
4. Solar PV inverter option #2 – Schneider Conext SmartGen CS2200

Power transformers

The power transformers for the Palmer Solar facility have not yet been tested or built and no reference levels of sound power exist for power transformers, so two separate industry-accepted standards will be used to estimate the sound power level of the Palmer Solar facility transformers. The largest of the two estimated values will be used for the estimation of sound level at the property boundaries.

Sound Power Level Estimation – IEEE Method

According to IEEE Standard C57.12.00-2015 Informative Annex C, the sound power level of power transformers may vary by manufacturer and the approximate sound power level L_{WA} may be calculated according to the following equation, with an error of +12dBA to -6dBA:

$$(1) \quad L_{WA, Ir} = 43.6 + 18 \log_{10}(S_r)$$

Where:

- $L_{WA, Ir}$ is the estimated A-weighted sound power level of the transformer at rated current and rated frequency at the short-circuit [test] condition.
- S_r is the rated power in MVA.

Per this equation, the maximum sound power levels of the power transformers at the Palmer Solar facility are estimated as follows:

1. 63.8MVA substation power transformer sound power level: $L_{WA} = 76.1\text{dBA} + 12\text{dBA} = \mathbf{88.1\text{dBA}}$
2. 3.36MVA power station transformer sound power level: $L_{WA} = 53.1\text{dBA} + 12\text{dBA} = \mathbf{65.1\text{dBA}}$

Sound Power Level Estimation – NEMA Method

According to NEMA standard TR-1 Table 1, the transformer manufacturers must guarantee that the sound level of the transformers must not exceed the following values:

1. 63.8MVA substation power transformer sound level; manufacturer guaranteed: **81dBA**
2. 3.36MVA power station transformer sound level; manufacturer guaranteed: **64dBA**

Since the sound levels calculated using the IEEE method are larger, those values will be used for determination of the sound level at the property boundary.

Inverters

Two different inverters are proposed for the Palmer Solar project. The loudest of the two will be assumed for the purposes of this noise impact study.

TMEIC PVH-L3360GR

The sound levels of the PVH-L3360GR inverter have not yet been measured in a test environment. The sound levels of an inverter of similar construction, the PVH-L2700GR has been measured in a test environment and that test data has been provided by TMEIC in Appendix B. The sound levels of the PVH-L3360GR inverter are not expected to exceed those measured by the PVH-L2700GR. An error of 30% is assumed for the purposes of this noise impact study.

The loudest sound pressure level measurement from this inverter at 1m away is **61.7dBA + 30% = 64.0dBA**. Note that the additional 30% is applied to the sound pressure in Pa and converted back to dBA for this estimation.

Schneider Conext SmartGen CS2200

The sound levels of the CS2200 have been measured in a test environment and are provided in Appendix C.

The loudest sound pressure level measurement from this inverter at 1m away is **84.7dBA**.

The highest measured sound level of **84.7dBA** from the inverters will be assumed for the purposes of this noise impact study.

Method of Determination of Sound Level at Property Boundaries

In order to determine the audible noise levels at the property boundaries, the inverse square law is used. The following equation is used to determine the sound level at a distance away from the source:

$$(2) \quad I = \frac{P}{4\pi r^2}$$

Where:

- I is the sound intensity in W/m²
- P is the sound power in W
- r is the distance away from the source in m

This equation may be generalized with the following rule: as the distance from the noise source is doubled, the sound level will drop by 6dB. As the distance is increased by a factor of 10, the sound level will drop by 20dB. Sound absorption or reflection of the surrounding equipment, ground, and plant life are not considered for this study.

Applicable Property Boundaries

Two property boundaries were identified within the scope of this noise impact study:

- A. The shortest distance from a power station inverter and transformer to the property boundary was identified to be **290ft**.
- B. The distance from the substation transformer to the substation property boundary was identified to be **110ft**.

Calculation of Sound Level at Property Boundaries

Closest Power Station to Property Boundary

Since the power station transformers and inverters reside in roughly the same space, the loudest of the two will be considered for the sound level determined at the closest property boundary.

Since the sound power level of the power station transformers was calculated above, the sound pressure level at 1m away must be calculated for comparison with the inverter sound pressure level at 1m away. The power station transformer sound pressure level at 1m away of the is calculated per equation (2) to be **54.1dBA** based on a sound power level of 65.1dBA.

At the power stations, the source of the highest sound pressure level at 1m away was determined to be the inverters at **84.7dBA**.

At a distance of 290ft or 88m from the nearest power station, the highest sound level at the property boundary is calculated to be **45.8dBA** which falls within the acceptable noise levels for unincorporated El Paso county.

Substation Property Boundary

At a distance of 110ft or 24m from the substation transformer, the highest sound level at the substation property boundary is calculated per equation (2) to be **46.6dBA** which falls within the acceptable noise levels for unincorporated El Paso County.

Conclusion

The results of this noise impact study show that the *Ordinance Concerning Noise Levels in Unincorporated El Paso County* will not be violated at any of the property boundaries. This study shall be validated upon receipt of transformer and inverter test data from the manufacturers.

Appendix A

Ordinance Concerning Noise Levels in Unincorporated El Paso County

ORDINANCE NO. 02-1

**BOARD OF COUNTY COMMISSIONERS
COUNTY OF EL PASO, STATE OF COLORADO**

**ORDINANCE CONCERNING NOISE LEVELS
IN UNINCORPORATED EL PASO COUNTY**

Commissioner Howells moved adoption of the following Ordinance:

WHEREAS, the Board of County Commissioners for El Paso County, Colorado, finds and declares that noise that exceeds the limits provided for within this ordinance is a major source of environmental pollution that represents a threat to the serenity and quality of life in El Paso County; and

WHEREAS, excess noise often has an adverse physiological and psychological effect on human beings and, thus contributes to an economic loss to the community; and,

WHEREAS, Section 30-15-401(1)(m) authorizes a Board of County Commissioners to adopt ordinances which control and regulate noise on public and private property within its jurisdiction; and

WHEREAS, the Board of County Commissioners finds that adopting a noise ordinance is in the best interests of the public health, safety, and welfare of the citizens of El Paso County; NOW, THEREFORE,

**BE IT ORDAINED BY THE BOARD OF COUNTY COMMISSIONERS
OF THE COUNTY OF EL PASO, COLORADO, AS FOLLOWS:**

SECTION 1. This ordinance shall be known and referred to as the "*El Paso County Noise Ordinance*."

SECTION 2. Scope of Ordinance: This Ordinance shall apply within the unincorporated territory of El Paso County. It shall not apply in those instances where state law, pursuant to C.R.S. §30-15-401 (1)(m)(II), specifically exempts certain activities. In situations contemplated by C.R.S. §25-12-109, it shall apply as limited by that Section.

SECTION 3. Definitions: The following definitions shall apply to this Ordinance:

(a) "Commercial Area" means:

- (1) An area where offices, clinics, and the facilities needed to serve them are located;
- (2) An area with local shopping and service establishments located within walking distances of the residents served;

- (3) A tourist-oriented area where hotels, motels, and gasoline stations are located;
 - (4) A large integrated regional shopping center;
 - (5) A business strip along a main street containing offices, retail business and commercial enterprises;
 - (6) A central business district; or
 - (7) A commercially dominated area with multiple-unit dwellings.
- (b) "Construction Activities" means any and all activity incidental to the erection, demolition, assembling, alteration, installation or equipping of buildings, structures, roads or appurtenances thereof, including land clearing, grading, excavating, well drilling, and filling.
- (c) "Device" means any equipment or mechanism which is intended to produce or which actually produces sound when installed, used or operated.
- (d) "Industrial Area" means an area in which manufacturing and/or other industrial activities are prevalent.
- (e) "Noise Disturbance" means any sound which is:
- (1) Harmful or injurious to the health, safety or welfare of any individual; or
 - (2) Of such a volume, frequency and/or intensity that it unreasonably interferes with the quiet enjoyment of life of an individual of ordinary sensitivity and habits; or
 - (3) Unreasonably interferes with the value of real property or any business conducted thereon.
- (f) "Person" means any individual, association, partnership or corporation, and includes any officer, employee, department, agency or instrumentality of any association, partnership or corporation, or the state or any political subdivision of the state.
- (g) "Property Boundary" means an imaginary line along the ground surface and its vertical extension, which separates the real property owned by one person from that owned by another person, but not including intra-building real property divisions.

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(h) "Public Right-of-Way" means any street, avenue, boulevard, highway, sidewalk or alley or similar place which is owned or controlled by a governmental entity.

(i) "Public Space" means any real property or structures thereon which are owned or controlled by a governmental entity.

(j) "Residential Property" means any property which is occupied by a residence, whether it be a single family, two-family or multi-family dwelling, or a mobile, manufactured or modular home, which is located within any zone district allowing a residence as a permitted principal use as set forth in the El Paso County Development Code, as amended.

(k) "Sound" means an oscillation in pressure, stress, particle displacement, particle velocity or other physical parameter, in a medium with internal forces. The description of sound may include any characteristic of such sound, including duration, intensity and frequency.

(l) "Sound level" means the weighted sound pressure level obtained by the use of the sound level meter and frequency weighing network, as specified in the American National Standards Institute Specifications.

(m) "Sound Pressure" means the instantaneous difference between the actual pressure and the average or barometric pressure at a given point in space as produced by sound energy

(n) "Sound Producing Device" means any equipment or machine for the production, reproduction or amplification of speech, music or other sound, including, but not limited to, radios, televisions, phonographs, tape players, musical instruments, compact disc or tape cassette players, walkie-talkies, CD radios or synthesizers.

(o) "Vehicle" means any device which is capable of moving itself or of being moved, from place to place upon wheels or endless tracks. "Vehicle" includes any bicycle, but such term does not include any wheelchair as defined by C.R.S. 42-1-102(113) (2001); any farm tractor or any implement of husbandry designed primarily or exclusively for use and used in agricultural operations; any device moved by muscle power; any device moved exclusively over stationary rails or tracks; or any device designed to move primarily through the air.

SECTION 4. Prohibited Activities:

(a.) It shall be unlawful to engage in any of the following activities, whether by use of a sound producing device, other device, or other means (either natural or artificial):

1. To knowingly permit, make, cause to be made or continue any noise disturbance, as defined in Section 3(e) of this Ordinance.

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2. To exceed the sound levels provided for in Section (5) and as measured as provided for in Section (6), below.
3. To operate a motor vehicle in a public right of way and exceed the sound level provided for in Section (5) and as measured as provided for in Section (6), below.
4. Knowingly and repeatedly sounding any horn or other auditory signaling device on or in any motor vehicle on any public right-of-way or public space, except as a warning of either danger or emergency.

SECTION 5. Maximum Permissible Noise Levels:

- (a) Sound levels shall be measured in db(A) as provided for in Section 6 of this Ordinance.
- (b) During the time periods indicated below, and on the types of property indicated below, the sound levels permitted by this Ordinance shall be observed:

<u>Land Uses</u>	Maximum Noise [db(A)] 7:00 a.m. - 7:00 p.m.	Maximum Noise [db(A)] 7:00 p.m. - next 7:00 a.m.
Residential property or Commercial area	55 db(A)	50 db(A)
Industrial area or Construction Activities	80 db(A)	75 db(A)
Non-specified areas	55 db(A)	50(db)(A)

- (c) In the hours between 7:00 a.m. and 7:00 p.m., the noise levels permitted by this section may be exceeded by ten (10) db(A) for a period not to exceed fifteen (15) minutes in any one (1) hour period.

- (d) Vehicles operating in the public right of way shall observe the following sound levels:

<u>Vehicle class (GVWR)</u>	Maximum noise in Speed Limit 35 m.p.h. or less zone	Maximum noise in Speed Limit over 35 m.p.h. zone [dbA]
Manufacturer's gross vehicle weight rating (GVWR) over 10,000 pounds (4,536 kg), or any combination of vehicles towed by such motor vehicle.	86	90

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Any other motor vehicle or
combination of vehicles towed by
any other motor vehicle, including
automobiles, vans, light trucks
or motorcycles.

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(e) Construction Activities are subject to the sound level permitted for industrial areas only for the period within which construction is to be completed pursuant to any applicable construction permit issued by proper authority or, if no time limitation is imposed, for a reasonable period of time to complete the project. At any other time, construction activities are subject to the sound level for the areas indicated above (residential, commercial, industrial, or non-specified).

SECTION 6. Classification and Measurement of Noise: For the purposes of measuring any noise to determine whether a person has violated Section 4(a)(2) or 4(a)(3) of this Ordinance, the following test measurements and requirements shall be applied:

- a. Any noise originating within a public right of way or other public land shall be measured at a distance of at least 25 feet from the noise source.
- b. Any noise originating on private property shall be measured at or within the boundary of the property from which a noise complaint is made.
- c. The noise shall be measured on a weighing scale on a sound level meter of standard design and quality and in accordance with the standards promulgated with the American National Standards Institute.
- d. For the purposes of this Ordinance, measurements with sound level meters shall be made when a wind velocity at the time and place of such measurement is not more than five (5) miles per hour, or more than twenty-five (25) miles per hour with a windscreen appropriately attached to the microphone.
- e. Vehicle noise shall be measured at a distance of at least twenty-five (25) feet from the near side of the nearest lane being monitored and at a height of at least four (4) feet above the immediate surrounding surface.

SECTION 7. Exceptions: The provisions of this Ordinance shall not apply to:

- (a) Any noise resulting from any authorized emergency vehicle responding to an emergency call or acting in time of emergency;
- (b) The operation of aircraft, or other activities which are preempted by federal law, with respect to noise control;
- (c) Operation of agricultural equipment;

- (d) Noise related to the normal operation of a railroad;
- (e) Any use of property for purposes of athletic or special outdoor events or any speed or endurance events involving motorized or other vehicles, but such exception is effective only where such use is authorized by resolution, variance, permit, or nonconforming use authorized by the political subdivision or governmental agency having lawful jurisdiction to authorize such use; or
- (f) Commercial well drilling.

SECTION 8. Violations and Penalties:

- (a) Violation of this Ordinance shall constitute a Class II petty offense. Violations of this Ordinance may be enforced through the penalty assessment procedure set forth in Section 16-2-201, C.R.S.
- (b) The graduated fine schedule for the penalty assessment procedure is:
 - \$ 30.00 for the first violation.
 - \$ 60.00 for the second violation within thirty (30) days of the first violation.
 - \$300.00 for each successive violation within thirty (30) days of the prior violation.
- (c) In addition to any other penalty, persons convicted of a violation of this Ordinance shall be subject to a surcharge of \$10.00 payable to the Clerk of the Court.
- (d) Any Law Enforcement Officer of El Paso County is authorized to issue citations, summons and complaints for violation of this Ordinance.

SECTION 9. Prosecution: All prosecutions for all offenses under this Ordinance shall be by the Fourth Judicial District Attorney according to the Colorado County Court Rules of Criminal Procedure.

SECTION 10. Effective Date: This Ordinance shall become effective for all covered activities 30 days after publication of the Title which occurs after the Second Reading by the County Commissioners.

SECTION 11. Severability: If any provision of this Ordinance is determined to be unconstitutional by any court of competent jurisdiction, the remaining provisions shall be deemed unaffected by said determination.

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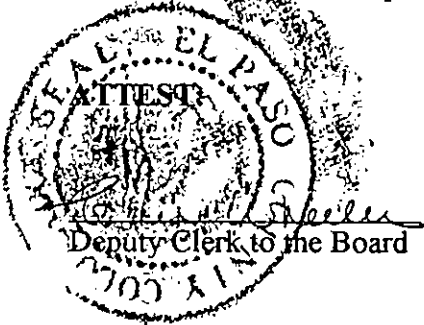
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FIRST READING:

INTRODUCED, READ AND ADOPTED ON FIRST READING on the 10th day of June, 2002, and ordered published in the El Paso County Advertiser and News.



**THE BOARD OF COMMISSIONERS
OF EL PASO COUNTY, COLORADO**

BY:



T.D. Huffman, Chair

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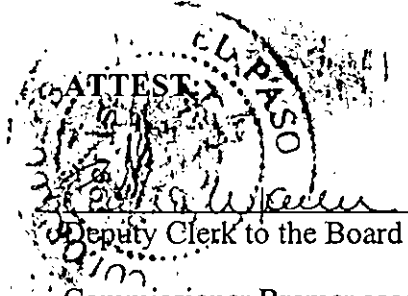
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SECOND READING:

ADOPTED ON SECOND AND FINAL READING on this 1st day of August, 2002.



**BOARD OF COUNTY COMMISSIONERS
OF EL PASO COUNTY, COLORADO**

By: _____

T.D. Huffman, Chair

Commissioner Bremer seconded the adoption of the foregoing Ordinance. The roll having been called, the vote was as follows:

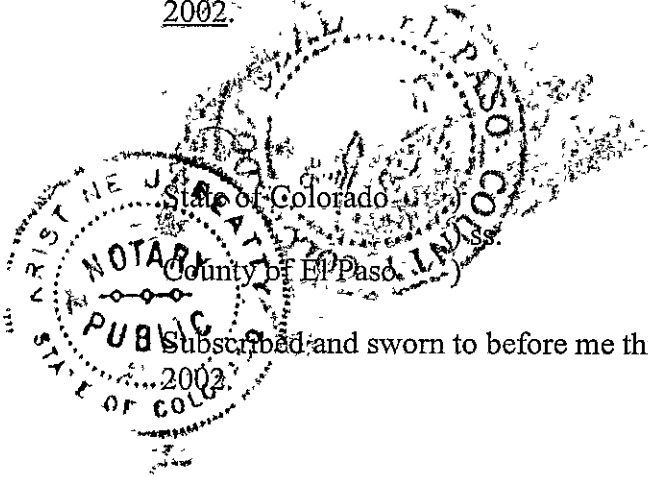
Commissioner Jones	absent
Commissioner Bremer	aye
Commissioner Brown	aye
Commissioner Howells	aye
Commissioner Huffman	aye

The Ordinance was unanimously adopted by the Board of County Commissioners of the County of El Paso, State of Colorado.

CERTIFICATE OF PUBLICATION AND ADOPTION

I hereby certify that the foregoing Ordinance No. 02-1 was introduced, read and adopted on first reading at the regular meeting of the Board of County-Commissioners of the County of El Paso on June 10, 2002, and the same was published in full in the El Paso County Advertiser and News, a newspaper of general circulation published in El Paso County, on June 12, 2002, and thereafter was adopted on second and final reading at a regular meeting of the Board of County Commissioners of the County of El Paso on August 1, 2002. Said Ordinance was published by reference to title only on August 7, 2002.


Deputy Clerk to the Board



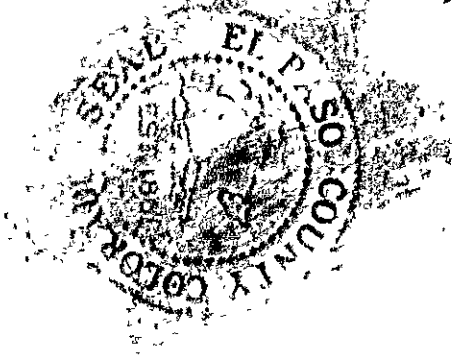
Subscribed and sworn to before me this 7th day of August, 2002.

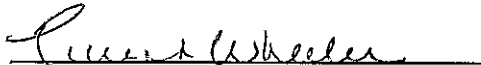

Notary Public

My Commission Expires: 8-8-2006

CERTIFICATION AS TO AUTHENTICITY

I, EILEEN L. WHEELER, El Paso County Deputy Clerk to the Board, do hereby certify that the foregoing Ordinance No. 02-1, entitled "An Ordinance Concerning Noise Levels in Unincorporated El Paso County" is a true, correct and complete copy from the records in my office, that said Ordinance was duly adopted by the Board of County Commissioners of El Paso County and is in full force and effect.




Deputy Clerk to the Board

J. Patrick Kelly El Paso Cty, CO

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ORDINANCE NO. 2002 - 1

**THE BOARD OF COUNTY COMMISSIONERS
OF THE COUNTY OF EL PASO, COLORADO**

**"AN ORDINANCE CONCERNING NOISE LEVELS IN
UNINCORPORATED EL PASO COUNTY"**

PLEASE NOTE: First Reading of Ordinance No. 2002- 1 was held on June 10, 2002, and Ordinance No. 2002- 1 was published in the El Paso County Advertiser and News on June 12, 2002. This Ordinance No. 2002- 1 was thereafter adopted on second and final reading on August 1, 2002, published by reference to title only on August 7, 2002, and will become effective 30 days from publication of the Title.

Appendix B

Measured Sound Pressure Levels for the TMEIC PVH-L2700GR Inverter

Acoustic Noise Measurement for 2700kW/2500kW/1350kW Series

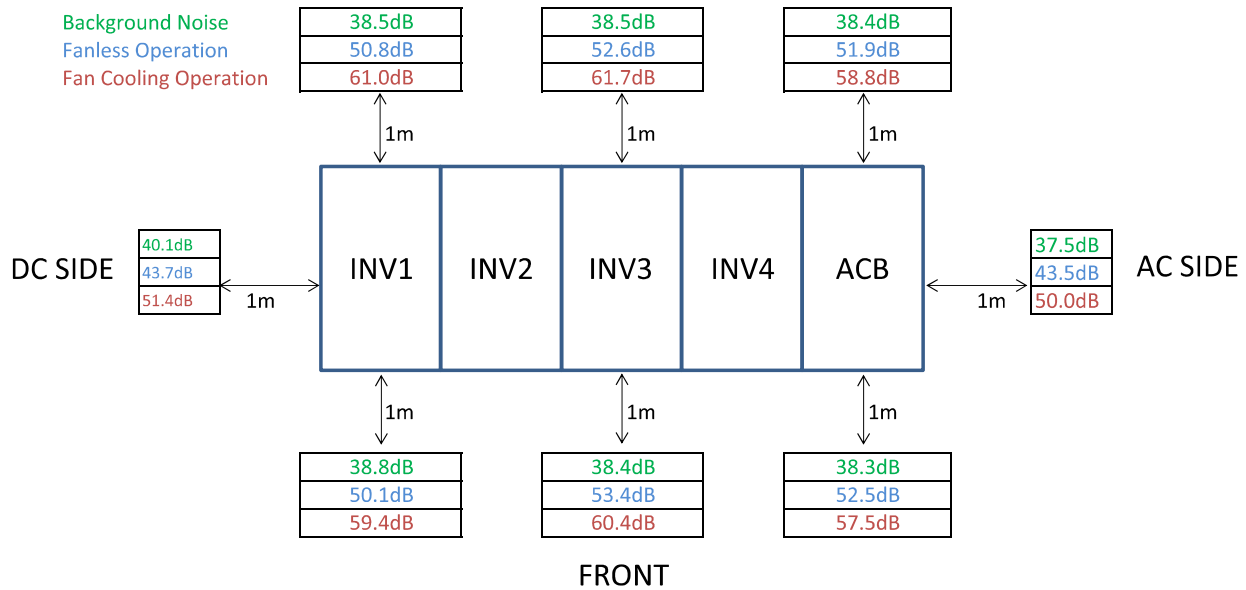
Test Specimen: PVH-L2700ER/PVH-L2500ER
Method: dBA peak value

Nov 24th 2016
FREA-G EMC Chamber

Result is also valid for
PVH-L2700GR, PVH-L2500GR



BACK



Appendix C

Measured Sound Pressure Levels for the Schneider Conext SmartGen CS2200

Conext SmartGen™ Series Inverter: Audible Noise Report

AP-SG-015
Revision A

Overview

This application note contains the audible noise test results for Conext SmartGen Series inverters. Average sound pressure level data was taken along the AC side, DC side, AC Connection end, Low Voltage (LV) and Communications end, and top of the inverter (see *"Acoustical Images and Discussion"* on page 3). *Table 1* and *Table 2* show the sound power levels and sound pressure levels.

Acoustical Images and Discussion

The following images are graphical representations of noise intensity levels. The directionality in the noise generation is modest. The center of the noise generation is at a height of about 1.5 m (4.9 ft). Fan noise is most prominent at the AC side and DC side of the unit (around the exhaust and intake area for the cooling system). The high-frequency switching noise at the 3.15 and 6.3 kHz is higher from the AC side than from the other sides, which indicates that most of the high frequency noise radiates from the lower middle section of the AC side enclosure panels, at a height of about 20 cm (7.9 in).

Figure 1 DC side (250 Hz, fan)

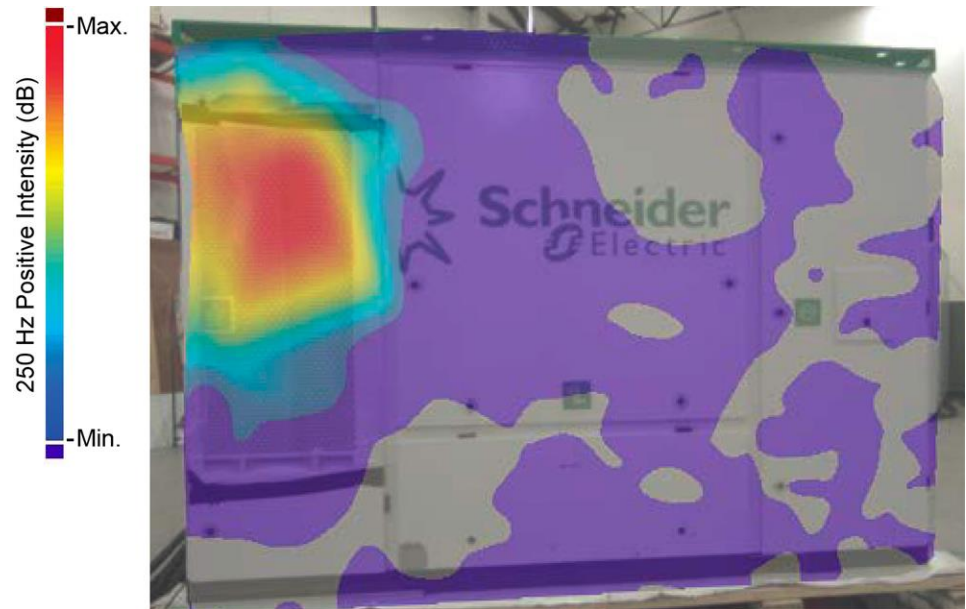


Figure 2 AC Connection end (250 Hz, fan)

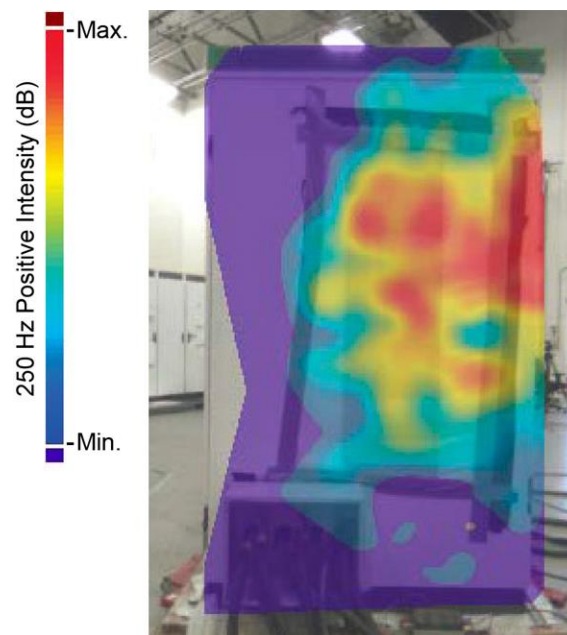
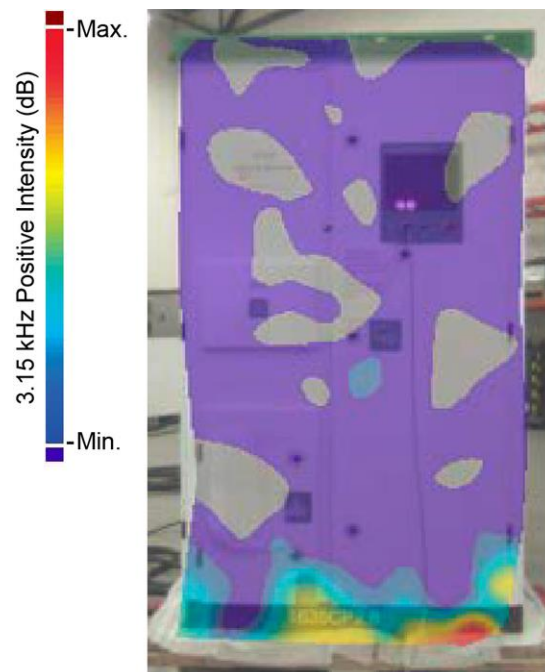


Figure 3 AC side (3.15 kHz, switching frequency)



Figure 4 LV and Communications end (3.15 kHz, switching frequency)



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Document Number: AP-SG-015

Revision A

Date: July 2017

Contact Information

For country-specific details, please contact your local Schneider Electric Sales Representative or visit the Schneider Electric Solar Business website at: <http://solar.schneider-electric.com/>