Sound Power

Kodiak 2.0 SC_UP

Noise Measurement

Revision History

Document Number SC4xxx-UP	Edition and Revision Type [1])		Annotations	Author
-910:LE2019	1.0	A	First Edition	S. Vorderbrügge

[1]) A: First Edition or minor modifications due to errors or improvements in the documentation.
This version replaces and invalidate former version in brackets.
B: Modifications maintaining full and upward compatibility.
This version replaces and invalidate former version in brackets.
C: Modifications limiting or excluding compatibility.
Valid only in combination with former version in brackets.

Tested by	25.06.2019 X Authorized signatory Signiert von: Stephan Vorderbruegge	**Released by**	25.06.2019 X Senior Ingenieur EMC & Global Certification (T TS TC EC) Authorized signatory Signiert von: Peter Thomae

Explanation of Symbols Used

For ensuring the understanding of this test report please note the following explanations of the symbols being used.

This symbol indicates an important comment.
For this reason read these sections carefully.

This symbol indicates an example.

This symbol indicates an opinion or an interpretation to circumstances.

Table of Contents

1 Overview of Results

Customer:	Manufacturer:	Test center:
SMA Solar Technology AG Sonnenallee 1 34266 Niestetal (Germany) Developer	**SMA** Solar Technology AG Miramstrasse 28 34123 Kassel (Germany) J. Alter	**SMA** Solar Technology AG Sonnenallee 1 EMC and Environmental Laboratory 34266 Niestetal (Germany) Building 4

Order number/account assignment:	85000947
Project title:	Kodiak-2_2019-04-17_FuMu2_Abnahme
Type of test / thresholds and requirements:	Sound Power level measurement according to DIN EN ISO 9614-2:2010-11 of sinusoidal, irregularly shaped, transient signals. Classification of ambient conditions in compliance with the German Noise Control Guidelines (TA Lärm). (according to Section 1.1.1)
Type of device:	e.g. solar central inverter for large-scale PV power plants
Type designation:	SC4600-UP of type SC4xxx-UP
Test specification:	Level of emissions according to the German Noise Control Guidelines and acoustic power
Tested by:	Stephan Vorderbrügge
Date of measurement:	13.05.2019

ID of the unit under test:

ID of the Unit Under Test:	3244		
Type designation:	SC4600-UP of type Kodial 2.0 SC_UP		
Serial number:	3004809309	**Hrdwareversion:**	B1 FuMu2.6
Option Code:	226D11EN2U1111120424100020008400031100000		
Aditional information:	36 PV-Inlets + DC-Coupling		
SW-Bundle:	06.00.20.B		
Device	**Serial number**	**Device**	**Serial number**
SC30CONT:	2752	SC30COM:	5094
SC30RIO:	4996	SC40GFDI:	Funktion sample
SC30ACC:	1481	SC30DCC:	15
SC30DCM:	4704 / 4499	SC40IMP:	Funktion sample
SC30Biene / SC30DST:	0504153172/ 0504153173/ 0504153431		

The results outlined in this inspection report only apply to the test item that has been tested. Any modification, e.g. in terms of the design, circuit technology or components used, can produce different test results.

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No research into additional relevant standards (such as ETSI standards in radio frequency applications, Bluetooth, etc.) applicable to this unit under test was carried out as part of this test.

It is therefore the responsibility of the client to obtain information in this regard.

Picture oft he EUT

1.1 Measured and derived levels

The EN 3744:04/2011, EN 9614-2:08/2011 and German Noise Control Guidelines form the testing specification for the thresholds and requirements	Requirement		4600 kW Serial U0N [dB_A]	XX kW Serial Standard [dB_A]	XX kW Silencer U0N [dB_A]	XX kW Silencer Standard [dB_A]	XX kW Silencer U0N [dB_A]	XX kW Silencer Standard [dB_A]
	Standard (Germany)	SMA						
EN 9614-2 **sound power L_{WA}** [3]	–	–	90,77	–	–	–	–	–
Sound pressure at a distance of 1m derived via Sound power level on Surface L_{pA} [2]	– [5]	– [5]	75,22	–	–	–	–	–
Sound pressure level in 10 m L_{xpA10} [4]	-	70	62,81-	–	–	–	–	–
Sound pressure level in 50 m L_{xpA50} [4]	**55** [1]	55	48,83	–	–	–	–	–
§48 of the German Federal Emission Control Act (BImSchG):09-2002 German Noise Control Guidelines; LPA 2) [5]	70	70	–	–	–	–	–	–
Overall result (if applicable)			Standard requirements: passed SMA requirements: passed					

Please note the detailed description of the measurement environment. See Section 3.2.2 Test Environment

[1] The Sound Pressure Level given at a distance of 50 m stands for the max level allowed at the system border of an industrial plant.

[2] Calculated average sound pressure level over the entire measurement area (see Section 8.1.1).Sound power resulting from sound intensity measurement (see Section 8.1.2).

3) Measured Sound Power Level via Sound Intensity on equal surfaces.

4) Calculated sound pressure level at the desired distance (see Section 5).

Dependent on the local standards and conditions at the mounting location (distance of 10m SMA standard, distance of 50m at the fence of industrial areas)

5) The value of the maximum sound level as stated in the German Noise Control Guidelines refers to the so-called vulnerable area (e.g. residential buildings, offices). This is dependent on the local conditions at the mounting location (see also Section 1.1.1). This applies in particular to large-scale PV power plants!

1.1.1 Emission Guide Values for the Rating Level According to the German Noise Control Guidelines

Criterion	Rating level in vulnerable areas inside buildings in dBA	Rating level outside buildings in dBA
A Industrial areas	By day 35	By day 70
	At night 25	At night 70
B Industrial parks	By day 35	By day 65
	At night 25	At night 50
C Core, village and mixed areas	By day 35	By day 60
	At night 25	At night 45
D Housing estates and small housing estates	By day 35	By day 55
	At night 25	At night 40
E Purely residential areas	By day 35	By day 50
	At night 25	At night 35
F Spas and hospitals	By day 35	By day 45
	At night 25	At night 35
Noise spikes above the rating level	By day 10	By day 30
	At night 10	At night 20

2 Carrying Out the Inspection

2.1 General Information

The noise level of a device must be agreed between the manufacturer and the user. This agreement must comply with the local requirements (German Noise Control Guidelines). After the manufacturer and the user have reached an agreement, a test needs to be carried out to determine the effect of noise radiating from the device. Other sources of noise during operation, e.g. fans, motors or other hydraulic-pneumatic mechanisms, must also be taken into consideration.

2.1.1 Inspection Reference According to EN ISO 3744:2011-02

EN ISO 3744 is used as the basis for determining the noise emissions of the unit under test according to EN ISO 12001:05-2007.
As part of the acoustics, it includes the determination of the sound level of noise sources using the enveloping surface method of accuracy class 2 for essentially free field conditions over a reflective plane. Measurements must be carried out in compliance with IEC 551 and DIN EN 45645-1 according to DIN EN ISO 3744. To position the measurement instruments, the enclosure of the unit under test is considered a main radiation area.

2.1.2 Inspection Reference According to EN ISO 9614-2:2010-11

The sound level is determined according to DIN EN ISO 9614-2
"Determination of sound power levels of noise sources using sound intensity"

Part 2: "Measurement by permanent scanning"
This measurement procedure keeps interference on the measurement result caused by noises from the environment to a minimum.

3 Operating States, Test Setup and Test Environment

3.1 Operating States

The following states and configurations have been defined as operating conditions:

- Operation of the inverter.
- Operating conditions: U_{DC}=1350 V; P I_{DC}=3450 A
- Operating conditions: U_{AC}=690 V; P 4600 kVA
- The device fans must be running at 100%.
- The unit under test must have reached its operating temperature.
- The unit under test must have reached an operating temperature of 25°C.

The following operating conditions and thresholds must be complied with (evaluation criteria):

- The extraneous noise level in the measurement environment must be kept as low as possible.
- The unit under test may not leave MPP operation.
- The unit under test may not leave feed-in operation.
- Error messages may not be displayed/issued.
- No function deviations are permitted.

3.2 Test Setup

Depending on the source of the sound (object to be tested), two different measuring arrangements can be used that give approximately the same **A**-rated measured values.

Procedure 1

Microphone arrangement on the hemispherical measurement area
In this case, values are recorded at a total of 32 measurement points. The table and the outlines set out in the standard DIN EN ISO 3744 must be complied with.

Procedure 2

Microphone arrangement on a cuboid measurement area
If not enough microphones are available (possibly only one), or if the dimensions of the unit under test are too small, a mobile microphone may be used to carry out the measurement. In this procedure, every flat surface, or side of the device enclosure, is considered individually and divided up so that each rectangular partial surface has edges 1 m long and is the same size as the others. The measurement microphone is now aligned at a measuring distance of 1 m from the surface of the unit under test at the mid-point of this imaginary rectangle.

Setting Up and Maintaining the Measuring Devices

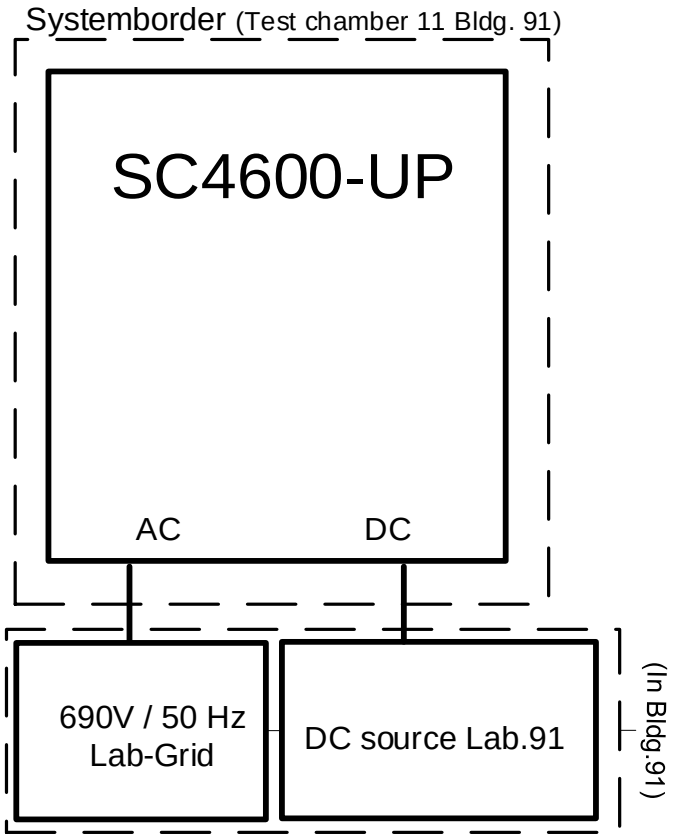
Sound pressure method

The microphones are aligned on a tripod above the stand space of the unit under test in the middle of the respective source of sound and at a measuring distance of 1 m. The measurement time per coordinate or side of the enclosure should be at least ten seconds, to ensure that fluctuations are reliably excluded.

Sound intensity method

The probe microphone is aligned above the stand space of the unit under test, perpendicular to the center of the respective sound source segment, at a measuring distance of 0.2 m and along a rather meandering route. The measurement time per coordinate field or side of the enclosure must be at least 20 seconds, to ensure that fluctuations are reliably excluded.

System Structure (Outline):



Lines and auxiliary equipment used			
EUT connection	Line	Auxiliary equipment/remote terminal	Notes
DC power supply	2 x 300 mm²	DC source SMA bldg. 91	-
AC feed-in	18 x 300 mm²	AC high-voltage transformer SMA bldg. 91	-
AC internal power supply	5 x 2,5 mm²	AC grid SMA bldg. 91	-
X501 (RJ45)	SFTP LAN line	PC/Notebook	-

3.2.1 Information About the Unit Under Test

- Dimensions of the unit under test (H x W x D): 2318 mm x 2780 mm x 1588 mm
- Device type of the unit under test:

Desktop device (80 cm above the floor)

The unit under test is set up on the table. The measurements are carried out.

at a distance of 1 m.

Floor-standing device with increased height > 90 cm .

The unit under test is set up on the floor. The measurements are carried out at a distance of 0,2 m.

3.2.2 Test Environment

- Test chamber 11 – lowest distance to walls or other structures: 5 m
- Measurement space – dimensions (H x W x D): 6,5 m x 11 m x 9 m – lowest distance from EUT to other structures: 5 m
- Increased ambient/test temperature of 27,34 °C
- Date of Test 13.05.2019

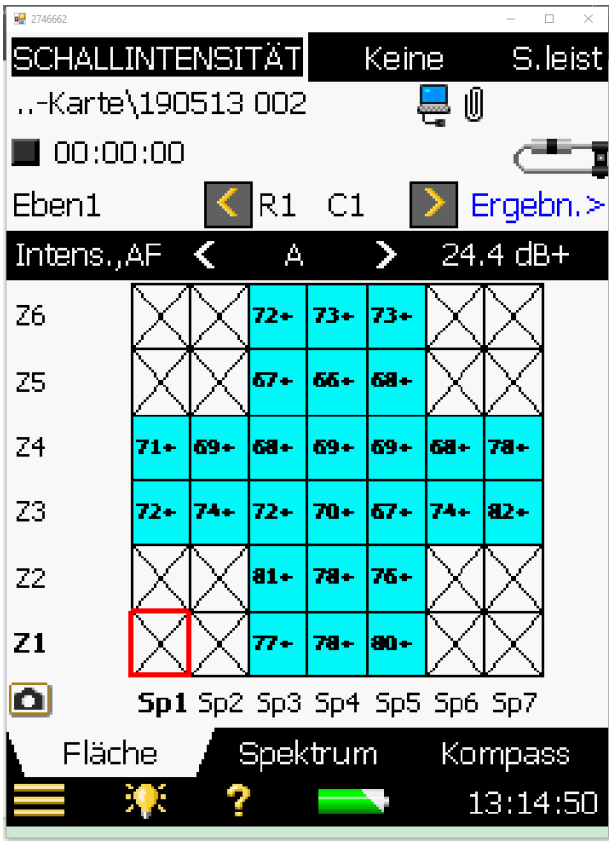
4 Determining the Sound Power L_{WA} According to EN ISO 9614-2

4.1 Determining the Overall Measurement Surface S and the Partial Measurement Surface PS

The surface of the measuring cube (not including base area) is the measurement surface S in m^2.

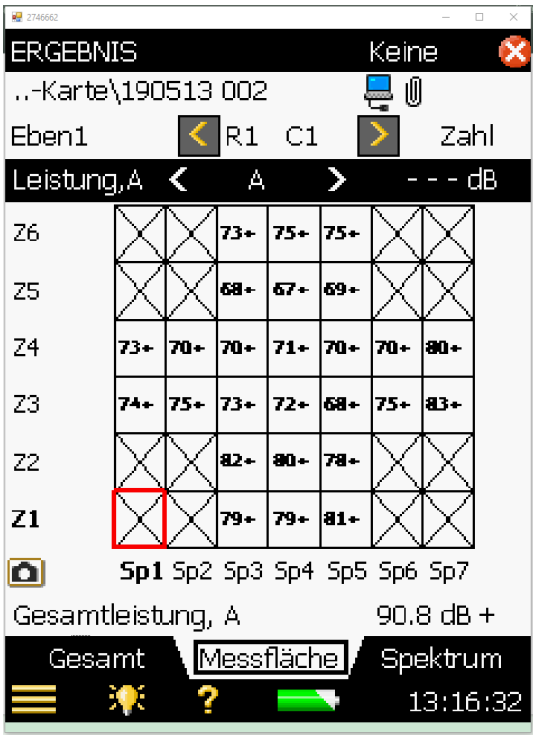
Cuboid measurement surface with 26 finite measurement surfaces of 1,25m x 1,1m.
Measurement surface **S=35,75m²**
Measurement distance **d = 0.2 m**

Measured Sound Intensoty on surface

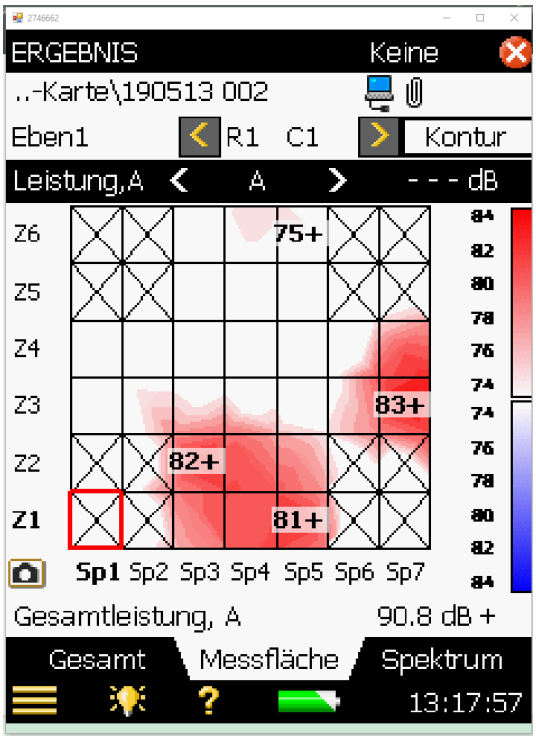


Fenite surfaces measured Sound Intesity on surfaces

Sound Power on suface Segments



Fenite surfaces



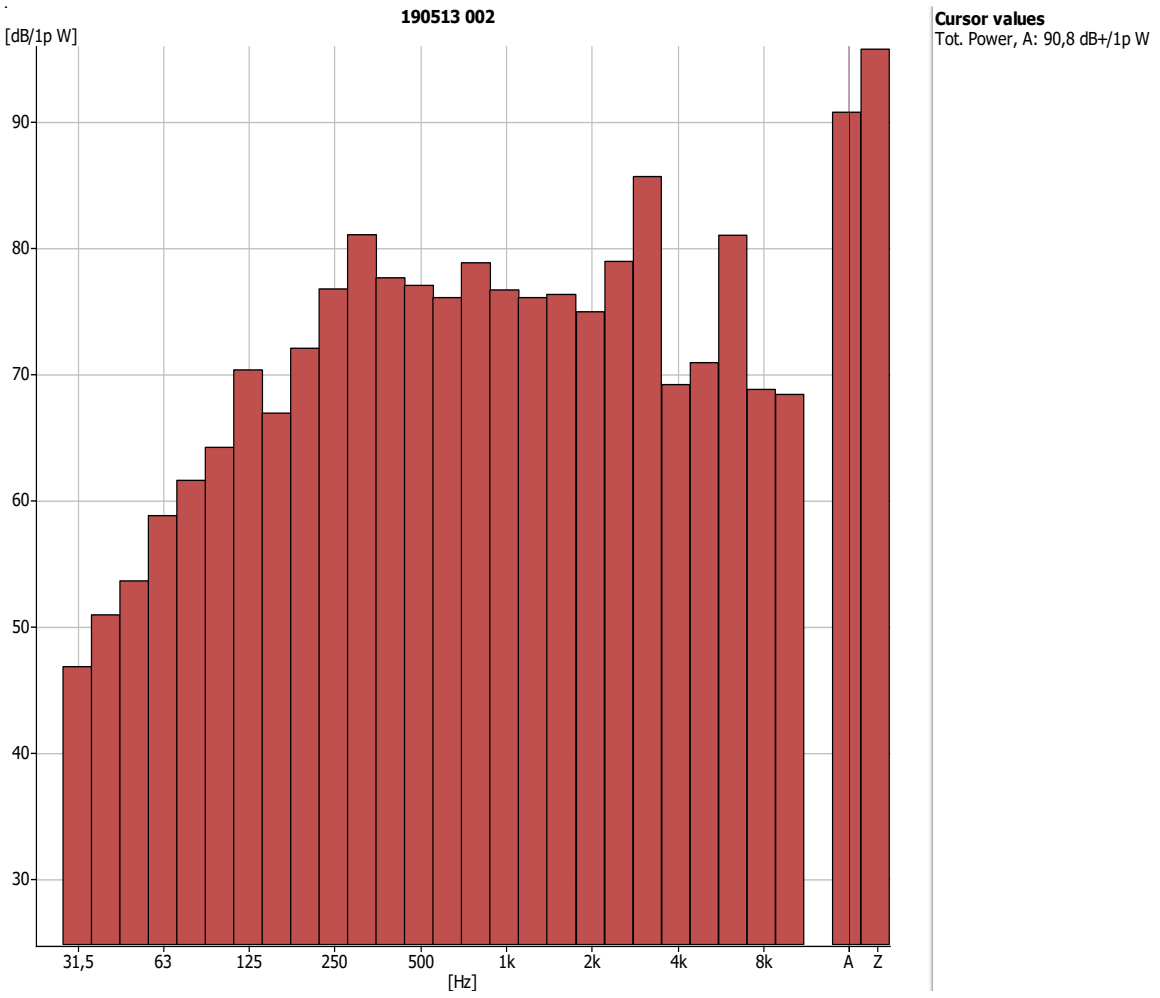
Sound Power on surfaces

Sound Power peak at surfaces

Exhaust seen on right side Z3 / Sp7

4.2 Measurement at 4600 kVA, 1350 V DC U0N modulation 100% fan load

Sound Power Levels of the Third Octave Band Frequencies according to EN ISO 9614-2



Overview of the Sound Power

Third octave band center frequency [Hz]	Sound - Power- level LwA [dBA/pW] 2475 kW
31,5 Hz	24,73
40 Hz	46,84
50 Hz	50,95
63 Hz	53,64
80 Hz	58,81
100 Hz	61,6
125 Hz	64,22
160 Hz	70,35
200 Hz	66,93
250 Hz	72,07
315 Hz	76,77
400 Hz	81,06
500 Hz	77,65
630 Hz	77,05
800 Hz	76,08
1 kHz	78,84
1,25 kHz	76,69
1,6 kHz	76,08
2 kHz	76,33
2,5 kHz	74,96
3,15 kHz	78,95
4 kHz	85,67
5 kHz	69,19
6,3 kHz	70,93
8 kHz	81,02
10 kHz	68,81
A	**90,77**
Z	95,76

5 Deriving the Emission Sound Pressure Level at a Distance

The calculated acoustic power can be used to derive an A-rated sound pressure level L_{xpA} for undirected sources at any distance x.

$$LxpA = LwA + Ko - 10 \cdot \log\left(4 \cdot \pi \cdot \frac{X^2}{So}\right)$$

K_0 = solid angle index on the floor 3 [dB]

X = distance from the source [m]

S_0 = 1 m

Device	Distance X [m]	Sound pressure level L_{xpA} [dB_A] 4600 kVA U0N without silencer	Sound pressure level L_{xpA} [dB_A] XX kVA standard with silencer
SC4600-UP	10	63	
	50	49	

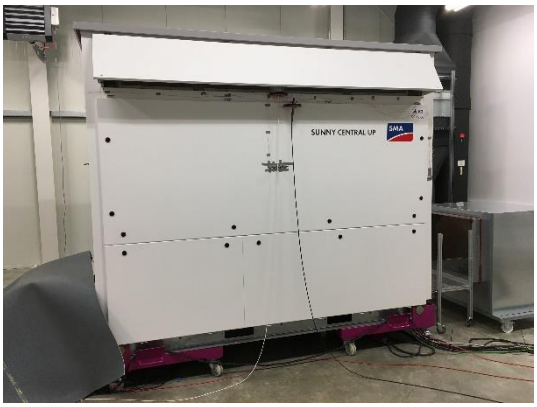
6 Measurement Equipment Used

Used	Type	Model	Manufacturer	Serial number/inventory number	Last/next calibration
X	Sound level meter	2250 A / E	BRÜEL&KJÄR	2611671	2017-05-15 / 2019-05
X	Class 1 acoustic calibrator	Kal-4231	BRÜEL&KJÄR	2615483	2017-05-15 / 2019-05
X	Class 1 Falcon microphone	MI-4189	BRÜEL&KJÄR	2616324	2017-05-15 / 2019-05
X	Sound analyzer	2270 A / E	BRÜEL&KJÄR	2746662	2017-05-15 / 2019-05
X	Class 1 Falcon microphone	MI-4189	BRÜEL&KJÄR	2771953	2017-05-15 / 2019-05
X	Intensity probe	IP-2683	BRÜEL&KJÄR	2759069	2017-05-15 / 2019-05
X	Class 1 Set microphone	MI-4197	BRÜEL&KJÄR	2751711	2017-05-15 / 2019-05
X	Intensity calibrator Class 1	Kal-4297	BRÜEL&KJÄR	2774959	2017-05-15 / 2019-05
X	Frequency analysis software	BZ-7223	BRÜEL&KJÄR	–	–
X	Signal recording sofware	BZ-7226	BRÜEL&KJÄR	–	–
X	Tonal analysis software	BZ-7231	BRÜEL&KJÄR	–	–
X	FFT measurement software	BZ-7232	BRÜEL&KJÄR	–	–
X	Tripod	C 3060	CULLMANN		–
	Full anechoic test chamber	Measuring section up to 3 m	Ing Thomas/SMA	–	–
	Semi-anechoic test chamber	Measuring section up to 5 m	Albatros/SMA	–	–
X	Test chamber 11 Bldg. 91	–	SMA	–	–
	Free-field measurement	–	–	–	–

6.1 Test Setup

The test is set up in accordance with the normative specifications and documented in the following "Photographs of the plant".

Photographs of the Plant



7 Appendix

7.1 Calculations

7.1.1 the Sound Pressure

L_{WA} =	Sound Power Level via Sond Intensity	90,77
S =	overall measurement surface [m^2]	35,75
S_0 =	1 [m^2]	
L_{pA} =	average sound pressure level at a distance of 1m[dB_A] *	**69,47**

* This specified spatially/temporally averaged sound pressure level was determined using the calculated sound power level.

$L_{PA} = L_{WA} – 10log (S/S_0)$

Sound power of L_{WA}= **90,77$dB_{A/W}$** results for the measurement.

A-rated sound power = **90,77 $dB_{A/W}$**
Z-rated sound power = 95,76 $dB_{A/W}$

A-rated acoustic power – based on physiologic human hearing
Z-rated acoustic power – technically linear measured value

7.1.2 Deriving the Emission Sound Pressure Level at a Distance

The calculated acoustic power can be used to derive an A-rated sound pressure level L_{xpA} for undirected sources at any distance x.

$$LxpA = LwA + Ko - 10 \cdot \log\left(4 \cdot \pi \cdot \frac{X^2}{So}\right)$$

K_0 = solid angle index on the floor 3 [dB]

X = distance from the source [m]

S_0 = 1 m

The following formulas are used to calculate the required values for the previous sections.

deriving sound pressure level at a distance
LxpA=LWA+K0-10log(4*PI*(x²/S0))

LWA	90,8	dB		
K0	3	dB	**LxpA**	**62,81 dBA**
x	10	m		
S0	1	m		

Surface deriving
(Without bottom according to standard)

Distance / m 0,2

		Length / m	Hight / m	Surface
	front	2,78	2,318	8,01 m²
	left	1,588	2,218	4,81 m²
automaticly	rear	*2,78*	*2,318*	8,01 m²
automaticly	right	*1,588*	*2,218*	4,81 m²
	top	2,78	1,588	6,32 m²
			coplete surface:	**35,75 m²**

RMS Sound presure level ontof measurement surface
(via sound intensity)

LpA=LWA-10log(S/S0)

LWA	90,8 dB		
S	35,75 m²	**LpA**	**75,27 dBA**
S0	1 m²		

7.2 Definition of Terms

Area Affected by a Plant

The area affected by a plant includes areas in which the noises coming from the plant

a) generate a rating level that is less than 10 dB(A) below the emission guide value specified for this area, or

b) generate noise peaks that reach the emission guide value specified for their rating.

Defining a Significant Emission Area (German Noise Control Act)

Significant emission areas are,

a) in the case of built-up areas, 0.5 m away from the center of the open window of the vulnerable area that is most affected by the noise, in accordance with DIN 4109, (german version) dated November 2009;

b) in the case of undeveloped land or built-up areas in which no buildings contain vulnerable areas, at the edge of the area that is most affected, where buildings with vulnerable areas are permitted according to building and planning law; in vulnerable areas that are similar in structure to the plant to be evaluated, in terms of structure-borne sound transfer and the effect of low-frequency noises in the vulnerable areas that are most affected. In addition, the provisions of DIN 45645-1, (german version) dated July 2006, section 6.1 regarding substitute measurement areas, arranging the microphone and carrying out the measurement apply.

Sound Pressure p

The change in pressure caused by sound that is superimposed on the static air pressure. It is given in pascals.

Sound Pressure Level Lp or LAF(t)

Definition: Ten times the common logarithm of the ratio of the squared sound pressure to the square of the reference sound pressure. The sound pressure level is given in decibels. The reference sound pressure is 20 µPa (2 x 10^{-5} Pa).

The sound pressure level LAF(t) is the instantaneous value of the sound pressure level formed using frequency weighting A and time weighting F according to DIN EN 60651, (german version) dated May 2004. It is the main basis for determining the level according to this "Technical Manual."

Average Level LAeq

The sound pressure level of a continuous, steady noise for which the sound pressure, within the averaging period T, has the same root mean square value as the time-dependent noise to be examined.

The average level LAeq is the time-based average for the sound pressure level based on the course of the sound pressure level over time, as per DIN 45641 (german version) dated June 2009, or as derived with the help of sound level meters, as per DIN EN 60804 (german version) dated May 2004.

Short-Term Noise Peaks

Short-term noise peaks in the sense of this "Technical Manual" are maximum values of the sound pressure level caused by individual events that occur during normal operation. Short-term noise peaks are described using the maximum level LAFmax of the sound pressure level LAF(t).

Acoustic Power W

The sound energy radiating from a source as airborne noise divided by the time. It is given in watts.

Average acoustic power level

The average acoustic power level LWeq is the average level of acoustic power over the exposure time. The frequency rating or radio spectrum to which the average acoustic power level applies is indicated by indices, e.g. LWA, LWOkt.

Acoustic Power Level Relevant for Emissions

Definition: Ten times the common logarithm of the ratio of the acoustic power radiating from the converter station to be tested to the reference sound pressure. It is given in decibels.
The acoustic power level of an installation that is relevant for emissions is the acoustic power level resulting from the total acoustic power of all sound sources within the installation, not including losses on the propagation path within the installation and taking into consideration the directivity measurements of the sound sources. It can, for example, be determined using an all-round measurement according to ISO 8297, (german version) dated December 2004.

Structure-Borne Sound Transfer

In the event of structure-borne sound transfer, the sound is transferred from the source via the floor and/or components to the boundary surfaces of the vulnerable areas.

Summary: Exhibit from the Angelina Solar I, LLC hearing held on 10/29/20 - CCPC 7, CCPC 9 and Company 28 electronically filed by Mr. Ken Spencer on behalf of Armstrong & Okey, Inc. and Burke, Carolyn