

Technical Documentation Wind Turbine Generator Systems 2.x-127 with LNTE - 60 Hz



Product Acoustic Specifications Normal Operation according to IEC

Incl. Octave and 1/3rd Octave Band Spectra

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1 Introduction

1.1 General

This document summarizes the acoustic emission characteristics of 2.x-127 with Low Noise Trailing Edge (LNTE) wind turbine for normal operation, including apparent sound power levels $L_{WA,k}$, as well as uncertainty levels associated with the sound power levels, tonal audibility, and octave and $1/3^{\text{rd}}$ -octave band sound power levels.

All provided sound power levels are A-weighted.

GE continuously verifies specifications with measurements, including those performed by independent institutes.

1.2 Wind Farm Noise Management (available as an option)

In noise-constrained areas it is often necessary to adapt the wind turbine operation to satisfy far-field noise limits. GE offers a dedicated Farm Noise Management system that provides greater flexibility and higher energy yield than standard turbine controls. This advanced scheme allows to continuously adjust the farm operation based on the environmental variables that influence farm noise emission, essentially wind speed and wind direction.

The Wind Farm Noise Management package includes the following service and hardware:

- Park level noise propagation modeling and optimization of wind farm operation,
- Table with optimum turbine set-points across the park as a function of wind speed and wind sector,
- Installation and commissioning of the Farm Noise Management Software Package.

2 Normal Operation Apparent Sound Power Levels

The apparent sound power levels $L_{WA,k}$ are given as a function of the hub height wind speed v_{HH} . The corresponding wind speeds v_{10m} at 10 m height above ground level have been derived assuming a logarithmic wind profile. In this case a reference surface roughness according to IEC 61400-11 of $z_{0,ref} = 0.05$ m has been used, which is representative of average terrain conditions¹.

$$v_{10m} = v_{HH} \frac{\ln\left(\frac{10m}{z_{0,ref}}\right)}{\ln\left(\frac{\text{hub height}}{z_{0,ref}}\right)} \quad ^2$$

The apparent sound power levels $L_{WA,k}$ and the associated octave-band spectra are given in Table 1 for different hub heights. The values are provided for Normal Operation (NO) turbine mode.

¹ Note, that under site-specific conditions, other values of roughness length might be appropriate.

² Simplified from IEC 61400-11, ed. 2.1: 2006 equation 7

Normal Operation - A-weighted Octave Spectra [dB]												
Hub Height Wind Speed [m/s]	4	5	6	7	8	9	10	11	12	13	14	15
Wind speed at 10 m height for a hub height of 89 [m/s]	2.8	3.5	4.2	5.0	5.7	6.4	7.1	7.8	8.5	9.2	9.9	10.6
Wind speed at 10 m height for a hub height of 114 m [m/s]	2.7	3.4	4.1	4.8	5.5	6.2	6.9	7.5	8.2	8.9	9.6	10.3
Wind speed at 10 m height for a hub height of 134 m [m/s]	2.7	3.4	4.0	4.7	5.4	6.0	6.7	7.4	8.1	8.7	9.4	10.1
Frequency [Hz]	16	56.4	55.7	58.3	61.0	64.0	68.1	68.8	68.8	68.8	68.8	68.8
	32	71.1	70.0	72.5	75.1	78.0	82.1	82.8	82.8	82.8	82.8	82.8
	63	80.8	79.9	82.6	85.1	88.1	92.0	92.6	92.6	92.6	92.6	92.6
	125	85.3	86.7	89.8	92.0	94.1	96.6	97.2	97.2	97.2	97.2	97.2
	250	87.2	89.9	93.8	97.0	98.8	97.8	98.2	98.2	98.2	98.2	98.2
	500	88.7	88.7	92.9	97.2	100.3	100.1	100.4	100.4	100.4	100.4	100.4
	1000	89.4	87.6	90.9	94.8	99.0	103.0	103.8	103.8	103.8	103.8	103.8
	2000	87.6	86.6	89.3	92.1	95.6	101.4	102.7	102.7	102.7	102.7	102.7
	4000	80.2	80.9	83.7	86.3	89.2	93.9	95.0	95.0	95.0	95.0	95.0
	8000	62.0	63.6	67.2	70.2	73.3	76.5	76.9	76.9	76.9	76.9	76.9
Total Sound Power Level [dB]	95.2	95.4	98.9	102.4	105.3	107.7	108.5	108.5	108.5	108.5	108.5	108.5

Table 1: Normal Operation Apparent Sound Power Level as a function of wind speeds

3 Uncertainty Levels

The apparent sound power levels given above are mean values of representative batches of turbines under evaluation. Uncertainty levels are not included. The uncertainty levels u_c , σ_P , σ_R and σ_T associated with measurements and mean values are described in IEC 61400-11 and IEC/TS 61400-14.

For GE wind turbines, a typical value of $\sigma_P = 0.8$ dB can be assumed.

The uncertainties for octave and $1/3^{rd}$ -octave sound power levels are generally higher than for total sound power levels. Guidance is given in IEC 61400-11.

4 Tonal Audibility

The tonal audibility, when measured in accordance with the IEC 61400-11 standard, for the 2.x-127 with LNTE is $\Delta L_{a,k} \leq 4$ dB.

5 IEC 61400-11 and IEC/TS 61400-14 Terminology

- $L_{WA,k}$ is the wind turbine apparent sound power level (referenced to $10^{-12}W$) measured with A-weighting as a function of wind speed. Derived from multiple measurement reports per IEC 61400-11, it is considered to be a mean value.
- u_c is the measurement uncertainty for acoustic testing as defined in IEC 61400-11. It is not a characteristic of the product, but of the measurement, and cannot be specified by GE. For average testing conditions, typical values of u_c are 0,7 dB – 1,0 dB.
- σ_P is the 2.x-127 unit-to-unit product variation according to IEC/TS 61400-14. It is a characteristic of the product and can therefore be specified by GE (see chapter 3).
- σ_R is the overall measurement testing reproducibility as defined in IEC/TS 61400-14. It is not a characteristic of the product, but of the measurements, and cannot be specified by GE. For typical testing according to IEC 61400-11, a value of $\sigma_R = 0,5$ dB is widely accepted.
- σ_T is the total standard deviation combining both σ_P and σ_R (see IEC/TS 61400-14).
- $\Delta L_{a,k}$ is the tonal audibility according to IEC 61400-11, described as potentially audible narrow band sound

6 1/3rd-Octave Band Spectra

The tables in Annex I are showing the 1/3rd-octave band values for different wind speeds.

7 Reference Documents

- IEC 61400-11, wind turbine generator systems part 11: Acoustic noise measurement techniques, ed. 2.1 (2006-11), or ed. 3 (2012-11)
- IEC/TS 61400-14, Wind turbines – part 14: Declaration of apparent sound power level and tonality values, ed. 1 (2005-03)
- MNPT – Machine Noise Performance Test, Technical documentation

Annex I - 1/3rd-Octave Band Apparent Sound Power Level $L_{WA,k}$

Normal Operation - 1/3 rd -Octave Spectra [dB]												
Hub Height Wind Speed [m/s]	4	5	6	7	8	9	10	11	12	13	14	15
Wind speed at 10 m height for a hub height of 89 [m/s]	2.8	3.5	4.2	5.0	5.7	6.4	7.1	7.8	8.5	9.2	9.9	10.6
Wind speed at 10 m height for a hub height of 114 m [m/s]	2.7	3.4	4.1	4.8	5.5	6.2	6.9	7.5	8.2	8.9	9.6	10.3
Wind speed at 10 m height for a hub height of 134 m [m/s]	2.7	3.4	4.0	4.7	5.4	6.0	6.7	7.4	8.1	8.7	9.4	10.1
Frequency [Hz]	12.5	42.0	41.9	44.7	47.5	50.6	54.8	55.6	55.6	55.6	55.6	55.6
	16	49.4	48.9	51.6	54.3	57.3	61.4	62.2	62.2	62.2	62.2	62.2
	20	55.3	54.5	57.1	59.7	62.7	66.8	67.5	67.5	67.5	67.5	67.5
	25	60.5	59.5	62.0	64.6	67.6	71.7	72.4	72.4	72.4	72.4	72.4
	32	65.2	64.0	66.5	69.2	72.1	76.2	76.9	76.9	76.9	76.9	76.9
	40	69.3	68.1	70.6	73.3	76.2	80.3	81.0	81.0	81.0	81.0	81.0
	50	72.5	71.4	74.0	76.6	79.5	83.6	84.2	84.2	84.2	84.2	84.2
	63	75.6	74.6	77.2	79.8	82.8	86.7	87.3	87.3	87.3	87.3	87.3
	80	78.2	77.5	80.1	82.6	85.6	89.5	90.1	90.1	90.1	90.1	90.1
	100	79.9	79.8	82.5	84.9	87.6	91.3	91.9	91.9	91.9	91.9	91.9
	125	80.6	81.8	84.8	87.0	89.1	92.0	92.6	92.6	92.6	92.6	92.6
	160	81.0	83.4	86.7	89.0	90.6	92.3	92.8	92.8	92.8	92.8	92.8
	200	81.6	84.6	88.3	90.8	92.4	92.5	93.0	93.0	93.0	93.0	93.0
	250	82.3	85.3	89.2	92.3	94.0	92.9	93.3	93.3	93.3	93.3	93.3
	315	83.2	85.3	89.6	93.1	95.3	93.6	93.8	93.8	93.8	93.8	93.8
	400	83.4	84.4	88.8	92.8	95.5	94.0	94.2	94.2	94.2	94.2	94.2
	500	84.0	83.9	88.2	92.5	95.7	95.2	95.5	95.5	95.5	95.5	95.5
	630	84.3	83.2	87.2	91.9	95.4	96.4	96.8	96.8	96.8	96.8	96.8
	800	84.4	82.6	86.3	90.7	94.8	97.3	97.9	97.9	97.9	97.9	97.9
	1000	84.6	82.6	85.9	89.8	94.1	98.2	99.0	99.0	99.0	99.0	99.0
1250	85.1	83.2	86.2	89.6	93.7	99.0	100.1	100.1	100.1	100.1	100.1	
1600	84.0	82.6	85.3	88.3	92.1	97.9	99.2	99.2	99.2	99.2	99.2	
2000	82.9	82.0	84.7	87.4	90.8	96.7	98.0	98.0	98.0	98.0	98.0	
2500	81.0	80.8	83.4	86.0	89.2	94.7	96.0	96.0	96.0	96.0	96.0	
3150	78.3	78.9	81.5	84.1	87.0	92.1	93.3	93.3	93.3	93.3	93.3	
4000	74.5	75.5	78.2	80.9	83.8	88.1	89.1	89.1	89.1	89.1	89.1	
5000	69.3	70.7	73.8	76.6	79.5	83.2	83.7	83.7	83.7	83.7	83.7	
6300	61.7	63.3	66.8	69.8	72.9	76.1	76.5	76.5	76.5	76.5	76.5	
8000	50.6	52.2	56.1	59.3	62.6	65.8	66.1	66.1	66.1	66.1	66.1	
10000	36.4	38.0	42.2	45.8	49.5	52.8	52.9	52.9	52.9	52.9	52.9	
Total Sound Power Level [dB]	95.2	95.4	98.9	102.4	105.3	107.7	108.5	108.5	108.5	108.5	108.5	108.5

Table 2: Apparent 1/3rd-Octave Band Sound Power Levels (A-weighted) as function of Wind Speed

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